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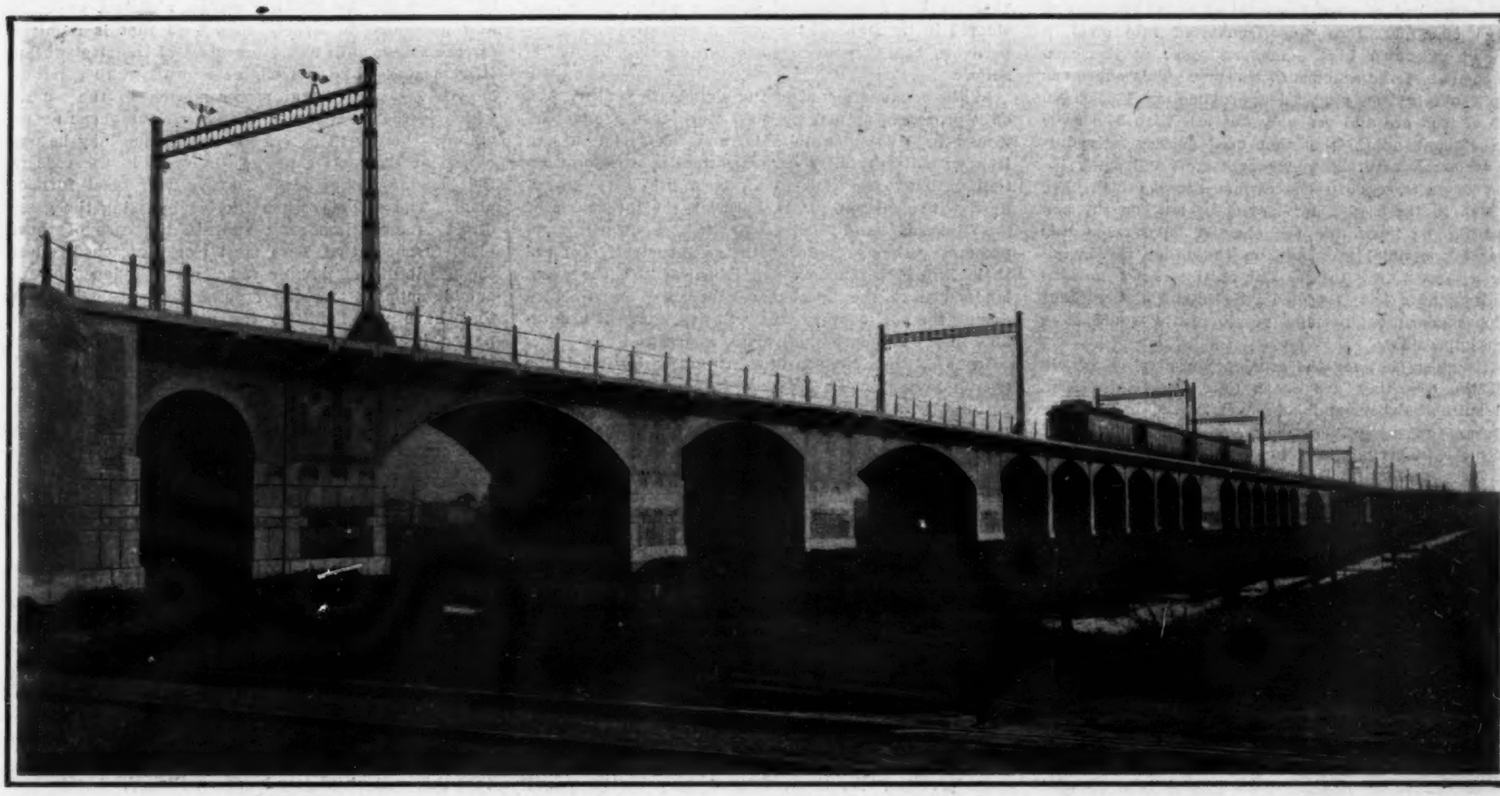


THE ROTTERDAM ARMORED CONCRETE VIADUCT.

THE TERMINUS AND YARD SECTION IN COURSE OF CONSTRUCTION.

AN ARMORED CONCRETE VIADUCT IN ROTTERDAM, HOLLAND.—[SEE PAGE 264.]

IRON AND STEEL.*

THEIR RELATION TO OTHER INDUSTRIES.

BY F. W. HARBORD.

In the industrial developments which the last 100 years have witnessed, I think we may claim that the great industry of iron and steel stands among the first. In 1806, just over a hundred years ago, the total production of the world did not exceed 800,000 tons of pig iron per annum, while in 1907 the annual production had reached the total of 58,973,000 tons of which 50,517,000 tons were converted into steel, a product unknown in the modern sense at the commencement of the nineteenth century. This enormous output of pig iron required approximately 129,000,000 tons of iron ore and probably not less than 95,000,000 tons of coal, apart from that used subsequently during its manufacture into wrought iron and steel.

I propose to consider the various causes which have assisted in these vast developments; how on the one hand the engineer and the chemist have made this progress possible, and how on the other the metallurgist, responding to the call of the varied modern requirements, has supplied the materials without which modern engineering developments would have been impossible.

It is clear that for the economic production of pig iron the essentials are cheap iron ores, cheap fuel, and suitable labor, and consequently the iron manufacturer is largely dependent upon the progress of mining engineering and cheap methods of transport for these materials. In 1806 a coal shaft 100 feet deep was an object of wonder, whereas to-day, in a modern pit, 2,000 tons of coal are raised per day through one shaft from a depth of 1,300 to 1,400 feet, and in some instances mines are working at a depth of 4,000 feet. The developments both in size and efficiency of modern pumping plants now render it possible for the mining engineer to face almost any volume of underground water at these great depths, while the winding engines, with which he is supplied, deal easily with the immense quantities of mineral at a maximum of speed and a minimum of cost. Rapid underground and surface traction and loading has reduced the cost of transport, and dressing has improved the value of the product, while the chemist with his modern explosives has enabled the miner to break ground in such quantities that his roads and hauling appliances can always be fully employed.

For raw material our modern iron and steel industries have been largely dependent upon the geologist and the prospector for the discovery of new deposits, and upon the mining and mechanical engineer for developing the ever-extending areas of suitable ore and fuel for their consumption. Admitting, however, how much we owe to the mining and mechanical engineers, on the other hand, without the materials supplied by the iron and steel metallurgists, cheap mining would have been impossible; the demand of the engineer for materials suitable for his boilers and his steam engines has been met by the metallurgist supplying him with a soft ductile plate for boilers, forgings of any strength required for engines, wire ropes of such a strength that deep haulage has been made possible, and steel castings of almost any shape and quality. Through the whole history of the industry it has been by mutual services rendered that progress on the one side has led to further progress on the other, so that while the engineer is ever, by improvement in design, obtaining greater efficiency and thus reducing costs, the steel maker is ever supplying him with a material suitable for his requirements.

The products of iron manufacture are pig iron, wrought iron, and steel. The first, the product of the blast furnace, supplies the raw material for the other two, and they may be regarded simply as purified pig iron.

The blast furnace has been in use in England for the manufacture of pig iron from very early times in Sussex, Gloucestershire, and South Wales, in close proximity to the large forests then existing, whence charcoal was readily obtainable, but the modern blast furnace may be said to date from about 1735, when Abraham Darby of Coalbrookdale first successfully used coke as the fuel; an improvement which was rapidly taken up by iron manufacturers in the various iron districts near the coal measures. Since Darby's time the invention which has had the most far-reaching result has been the use of the hot blast introduced by Neilson in 1828, which has enormously increased the output and efficiency of the blast furnace, and coupled with this is the utilization of the waste gases of the blast furnace, first for heating the blast for raising steam, and in comparatively recent times in internal-combustion engines.

The reverberatory furnace for puddling iron was introduced by Cort in 1774, revolutionizing the manufacture of wrought iron and practically superseding all others, while his invention of the grooved rolls in 1783 marked a mechanical advance which, when considered in the light of the present day steel works experience, has been even more far-reaching in its results.

At the commencement of the eighteenth century, the only processes of making steel were the crucible, invented by Huntsman in 1740, and the fusion of pig iron with its partial decarbonization, by the joint action of blast and slag in an open fire on a hearth lined with charcoal. It is, however, the inventions of the Bessemer and Siemens-Martin open-hearth steel processes, which, coupled with the introduction of the basic lining by Thomas and Gilchrist, are the great landmarks in the development of steel manufacture during the past century, and will ever make it memorable in the annals of industrial progress.

In 1828, when Neilson first introduced hot blast, the average output of an ordinary furnace did not exceed 25 to 30 tons per week, and the coke consumption was not less than 45 to 50 hundredweight per ton, and it is only by gradual steps that our present large production of low fuel consumption has been attained. This has been made largely possible by the engineering skill which has designed blowing engines enabling high pressure blast to be used, and by means of improved hoists, automatic charging appliances, and a hundred and one details, has so increased the output and reduced the labor costs, that probably the blast furnace to-day, in proportion to the weight of material it produces, is the cheapest industrial machine in the world.

The application of the Siemens regenerative principle to the heating of the blast as introduced by Cowper and Whitwell, and the complete utilization of waste gases, has led to a great economy in blast furnace practice. As the result of very costly experiments, the best size of the blast furnace for the different classes of ore in different districts has been determined gradually, and a height of about 85 feet and 20 feet diameter at bosh has been found to be about the maximum limit for economic production. Above this size no increased output or economy in fuel is obtained, and the difficulty of getting coke sufficiently strong to stand the weight of the burden without crushing, and consequently the increased pressure of blast necessary to penetrate the burden, induces a tendency in the furnace to channel, and causes irregular working. Thus, those furnaces which were built 100 feet and higher, have been discarded in favor of the smaller furnace.

The high pressure and high temperature of blast used in modern practice is very severe on the furnace lining, and the wear in the neighborhood of the boshes was soon found to be most serious. This was met by the device of water-cooled blocks inserted in the brickwork of the furnace, by which means the life of furnace linings has been greatly increased. It is not too much to say that without the system of water cooling now generally employed, the rapid driving and large production of the American blast furnace plants would have been an impossibility.

Great improvements have been made in recent years in the delivery of the raw materials into the blast furnace. In place of the hand-filled barrows carried to the top of the furnace by inclined plane or vertical lift, and which then had to be hand tipped again on to the bell top of the furnace, the ore, flux, and fuel are now delivered from the chutes of bins into wagons on scales, and the weighed material is delivered automatically into the hoist skip, which travels up the inclined plane and automatically discharges the materials into the receiving hopper at the top of the furnace.

The economy of working is largely due to the great attention to detail, such as careful mixing of ores to insure a regular product, careful control of the temperature of the blast by means of pyrometers, and the most economic utilization of the waste gases. Although the waste gases have for many years been utilized for steam raising and similar purposes, it is only during the last few years that they have been successfully employed in internal-combustion engines. This problem presented considerable difficulties owing to the fine dust in suspension, but gradually, as the result of the labors of various inventors, methods of purification have been evolved, and in a number of works in this and other countries gas engines from 500 up to 2,000 horse-power are successfully employed and giving satisfactory results. In some iron and steel works where formerly the blast-furnace gases did little more than raise the steam necessary to supply the power for the blowing engine, sufficient power is now generated to largely supply all that is required for the rolling mill and other plant of the steel works. In some cases the gas engine is utilized to generate electricity at a central power station in the works, which is then distributed to the various shops as required, whereas in others the gas engine may be employed as the motive power direct, as in the case of the blowing engine for a Bessemer or blast furnace plant. The economy thus effected by using the gases direct is most important and, in the case of those blast furnaces that have steel works attached, offers the possibility of making them nearly independent of outside supplies of fuel for power purposes. To those that have not facilities for utilizing their surplus power in this way, especially if there are several blast furnace plants within a small area, the possibility of generating and distributing electric power to outsiders, for use either for lighting or power purposes, does not seem by any means an improbable development, when there is such a growing demand for cheap electric power in almost all industrial centers.

As a rival to the internal-combustion gas engine, we now have the reciprocating steam engine in combination with the steam turbine, which, in the opinion of many competent judges, is likely to prove more efficient than even the gas engine. Some blast-furnace plants are already equipped with steam turbines driven by steam raised by the waste gases, and possibly at no distant date, instead of having to use steam in our turbines, we may be able to employ the waste gases direct. The difficulties to be overcome are very considerable, but in view of the past engineering achievements, there seems nothing improbable in assuming that this will ultimately be accomplished.

Another question which is now receiving considerable attention is the dehydrating of the blast by cooling it to a temperature below zero before it enters the furnace. Furnaces for several years have been at work in America with the Gayley plant, and for over a year a plant has been in operation at Messrs. Guest, Keen, and Nettleford's works at Cardiff with marked success. Opinions may differ as to the extent of the economy, but it is now generally admitted that the advantages direct and indirect of dry blast are very considerable, and had it not been for the costly nature of the plant many more furnaces would have been equipped with air-drying plants before this. The first cost is undoubtedly a very serious consideration, but from a recent visit to the Cardiff plant, and from the latest information obtainable, the advantages in lower fuel consumption, greater regularity of working of the furnace, and greater control over the production of iron of any required grade, seem to justify the expenditure, and it is probable that other plants will soon be installed in this country. As a minor matter, although one of no small importance in view of the large amount of room required for tipping, the utilization of slag may be mentioned, and numerous attempts have been made to find some purpose for which it could be employed. To a small extent it has been used for cement manufacture and some excellent slag cement has been made, but this industry has not developed sufficiently to deal with any large proportion of the slag produced. It is used to some extent for ballast for railways and sidings, and the recent demand for waterproof roads has led to the introduction of tarmac, which in the future will enable a considerable amount to be usefully employed. Broadly, however, no satisfactory method of dealing with anything like the large amount of slag produced has been suggested, and for the man who succeeds in relieving the ironmaster from the cost of tipping room, apart from actually paying him for his slag, a fortune is waiting.

In the preliminary treatment of ores in recent years there have been considerable improvements effected. In some works gas calcining kilns have been introduced with success, and considerable progress has been made in briquetting fine ores both in Sweden and this country. Briquettes can now be produced which are not only strong enough to bear carriage, but can withstand, without disintegration, the combined action of temperature and pressure to which they are subjected in a modern blast furnace.

* Paper read before the Society of Chemical Industry.

The large production of the modern blast furnace in America has stimulated the English ironmasters to emulate the example, but so far not with complete success. In some cases the failure has been due to the different classes of ore used, but more frequently to trying to adapt our English plants to American conditions of working, when to obtain success a new plant especially designed with the accessories all duly proportioned would have been necessary. There seems no reason why a specially designed furnace working on 50 per cent ores and high-class coke such as we have in this country, should not be able to turn out its 300 to 350 tons per 24 hours, but to do this, not only the furnaces, but the blowing engines, hot blast stoves, blast mains, charging appliances, and all other accessories must be duly proportioned, and unless one can start with a clear field it is not generally easy to arrange all these matters. The saving effected by ore bins with automatic charging appliances in which labor is reduced to a minimum may appear very inviting, but the expenditure necessary is so great that it is only justified by results when the capacity of the furnace, the blowing engine plant, and all accessories are such that the charging apparatus can be kept working to its full capacity.

Mistakes are sometimes made in this country by not fully realizing that the economy in working, and the large production of certain plants, is due to the whole plant having been so designed that each part is in proportion, and that to increase the pressure or volume of blast is useless without a proportionate increase in hot blast stove capacity, facilities for charging, etc. The old question whether large outputs of American furnaces are not more than counterbalanced by the short life of the furnace, and whether our own practice of slower driving and longer life is not in the end more economical has been often discussed, but is really not a question which is worth serious discussion, except when a particular case can be considered. Generally speaking, American conditions of working are not possible in this country with our existing plants, and to attempt them is to court disaster; on the other hand, much progress has been made and is being made in our practice of modifying some of the American methods to suit our special requirements. Notwithstanding our many shortcomings it is no small satisfaction to know that in certain districts in England, working with extremely poor ores, we are producing pig probably as cheaply as anywhere in the world. Closely connected with the economies in blast-furnace practice are the great improvements that have been made in the manufacture of coke. The modern retort oven of the Otto-Hoffmann type produces a higher yield of coke than the old beehive oven at a greatly reduced labor cost, and the evolved gas is sufficient not only to coke the coal, but to leave a very considerable surplus for power purposes, which can be either used direct in internal-combustion engines, or for steam raising, or for other purposes. The Siemens principle of regeneration is utilized in most of these ovens, so that the sensible heat in the waste gases is recovered, and heated air is supplied for the combustion of the gas round the retorts. In some plants the gas which comes off during the first stages of coking is taken off through what is known as the rich gas main, and used for illuminating purposes, and the gas which comes off later is taken through a separate main and used for heating the ovens. In the earlier forms of these ovens the coking of a charge took 26 to 30 hours, but by detailed improvements this has gradually been reduced to 20 hours, and in some ovens it is claimed that the average time does not exceed 18 hours. Great, however, as is the saving by the complete utilization of the gases, to this has to be added the recovery of the by-products, tar, ammonia, and benzol. The ammonia may be recovered and sold as concentrated ammonia liquor, or it may be converted into sulphate. The tar may be sold as crude tar, or distilled for the recovery of the various tar oils where there is no local sale for the tar, but this treatment is better done at chemical works.

A plant of 100 coke ovens yields per year about 14,000 tons of tar, and nearly 3,000 tons of sulphate of ammonia, and in 1907 over 95,000 tons of sulphate of ammonia were produced in England from blast furnaces, coke ovens, and producer plants, and very large quantities of tar. The value of sulphate of ammonia may be taken as £12 per ton, so that the recovery of this by-product alone represented a saving of nearly £1,140,000 to the community.

No reference has been made so far to the facility of transport, and yet nothing probably during the last fifty years has had more vital influence on our great industries. By means of our modern steamboats and mechanical means for charging and discharging cargoes, distances have been almost annihilated, and in our own country iron districts which otherwise must have ceased to exist have been maintained in a state of prosperity by the importation of ores from Spain and other countries many hundreds of miles away, at a cost little, if anything, exceeding that at which local ores were formerly raised on the spot. In America ores are brought from the Lake Superior district 800 miles by land and water to the coal fields of Pennsylvania, at a cost which enables this district to hold its own against the whole of the States. In no less a degree has cheap transports made it possible to distribute our finished products all over the world, thus greatly increasing the demand and making possible those great developments in railways and other large engineering undertakings, which are such a feature of the last fifty years.

The manufacture of wrought iron in the puddling furnace was carried on exactly as first proposed by Cort on a sand bottom, until the year 1818, when Samuel Baldwin Rogers introduced the iron bottom to replace the sand, so that the iron could be worked in a bath of cinder or rich oxide of iron practically free from silica. This proposal was at first received with great indifference or considered impracticable, and it was only after much trouble and expense that it was given a fair trial, and the inventor never received the recognition which he deserved. Previous to this date the average production of the puddling furnace was about 8 tons per week, and by this device not only was the quality greatly improved, but the production of the furnace was very greatly increased. With this exception no important modification has been made in the puddling process, and it is carried on to-day as it was ninety years ago. Many attempts have been made to facilitate the operation by mechanical means, and much money and time have been spent in this direction, but none have been so successful as to be generally adopted. The use of gaseous fuel in the puddling furnace also has never been a success, and the old coal-fired reverberatory still holds its own. In some other directions, more especially in the mechanical treatment, by the introduction of the direct-acting steam hammer and sectional rolling mills, great advances were made and economies effected in the production of finished iron during the first half of the last century. In 1820 the first rail mill was introduced, previous to which time wooden or cast-iron rails had been used. As railways gradually developed these gave a great impetus to the production of wrought iron for rails and other purposes.

In the manufacture of crucible steel little advance was made between its introduction by Huntsman and Robert Heath's process of reducing manganese oxide with carbon in the crucible during melting in 1839. In 1856 Vickers introduced the manufacture of steel castings, the far-reaching effects of which are hardly realized even to-day. Every year the methods of casting and quality of the castings are being so improved, that results are obtained equal in many cases to forged material, and finished products of such intricate shapes are produced that it would be impossible to make them in any other way.

The old coke-hole, practically the same as 100 years ago, is still largely used, although, comparatively recently, the gas-fired furnaces on the regenerative principle have been introduced; and now electric furnaces are being employed on the Continent, and have in one or two cases been tried in this country.

The modern two regenerator gas-fired Siemens furnace or the Robinson-Pope furnace, capable of holding 10 to 12 crucibles, has been successfully used by various makers; the saving in fuel costs by their use is said to be nearly £2 per ton, but notwithstanding this saving they have not been generally adopted. The gas furnace is more costly to erect per ton of steel melted, but the chief objection seems to be that the same uniform heat cannot be obtained, and consequently all the pots are not ready to "teem" at the same time, and the quality of the steel varies; further, it is said that there is a greater absorption of sulphur from the gases than when steel is melted in coke furnaces, although from theoretical considerations this hardly seems possible. In my opinion it is only a question of time for the electric furnace to be largely adopted for the manufacture of what is now known as crucible steel, especially when charges of one ton and upward can be conveniently dealt with, although for small quantities of 1 hundredweight or less of special steels, the crucible will probably always hold its own. So far as the metallurgy of the crucible steel process is concerned, little change has been made, the highest classes of steel being still made from best cemented bars remelted in the crucible, or from mixtures of best Swedish iron recarbonized in the pot. The demand for a cheaper quality of steel has led to cheaper materials being used for the second-class qualities, and to-day large quantities of crucible steel are made from selected steel scrap, by melting this with Swedish pig iron or other recarbonizing material in pots. Special alloy steels, known as air-hardening steels, which are revolutionizing our machine shops, are largely, although not exclusively, made in the crucible by melting suitable mixtures.

The vast developments, however, which have characterized the steel industry during the last sixty years are due almost entirely to the Bessemer, open-hearth, and Siemens processes. These processes are worked to-day practically as when they were first introduced by their inventors and, since Mushet showed the necessity of using ferro-manganese, there has been no metallurgical discovery of paramount importance to record with the exception of the basic process. Apart from this and some comparatively minor metallurgical improvements, the development of both processes has been entirely in the direction of increased size of converters, furnaces, and appliances. The discovery of the basic process, by which burnt dolomite replaced silica as a lining, marked a new era in the steel industry of the world, and made available for steel manufacture enormous deposits of phosphoric ores which were before unworkable. It also enriched the world by the recovery of the phosphoric acid, which these ores contained, in such a form that it could be largely used for agricultural purposes. In the early days of the basic process it was generally considered that the phosphoric slag would have to be chemically treated to remove the iron and render the phosphoric acid soluble before it could be used as a manure; but experiments soon demonstrated that fine grinding was all that was necessary to render the phosphoric acid easily soluble in the soil, and that the iron and other constituents present had no deleterious effects. To-day the value of the slag is such that certain basic Bessemer works depend very largely for their profits on the sale of their phosphoric slag.

The effect of the basic process on the development of new districts is most marked in the case of Germany. Previous to 1880 the total production of pig in Germany did not exceed 2,500,000 tons, whereas in 1906 it had reached 12,293,825 tons, of which over 8,000,000 tons was basic pig iron made from local ores. With this exception, the development of the steel industry, like that of the blast furnace, is due far more to improvement in mechanical appliances and details of practice, than to new processes.

Our Bessemer converters have increased in size from 2 to 5 ton converters to 16 to 20 tons, and our open-hearth furnaces from 5 to 250 tons. In the early days of Bessemer practice the advantage of taking metal direct from the blast furnace and saving the cost of remelting in the cupola was recognized, but owing to the difficulties of obtaining metal of regular composition, and also of tapping the blast furnace at very frequent intervals, it was not generally used until the metal mixer or receiver was introduced. This is simply a large reservoir, sometimes gas-fired and sometimes not, in which metal from a number of blast furnaces is stored and is poured off as required into ladles and taken to the converters. These mixers, originally about 100 tons capacity, have been increased in size to hold 300 and 400 tons, and in one case in England 750 tons of molten metal. By mixing the products of several blast furnaces metal of very fair regularity is obtained, and to some extent a certain elimination of impurities effected; thus, the silicon is appreciably oxidized, and if manganiferous metal is mixed with metal high in sulphur, the sulphur can be considerably reduced. (To be concluded.)

LETTERS REGISTERED MORE THAN TWO THOUSAND YEARS AGO.

Translations, recently published, of some of the latest papyri found in Egypt lead us, according to Corriere della Sera, precisely into an office where letters were registered more than two thousand years ago. Among other things found was a statement of account, later used in wrapping a mummy belonging to the time of Ptolemæus Philadelphus. On the back of this papyrus, the front being occupied by entries made by the bookkeeper of a great estate in relation to receipts and distribution of wheat and barley, this statement is followed by a postal diary which certainly was kept quite irregularly. The diary begins with the sixteenth and ends with the twenty-third day of a month not named, and mentions the arrival and further travel of letters forwarded from a local post office. An entry says: "On the twenty-first day of the month, at the fifth hour, the postal rider escorting the mail from the south delivered to the postal clerk Phanias at this station two letters. These letters were later delivered by assistant postmaster Horos to the postal rider Nikodemos, who departed with them for the north." This papyrus relates also that the chief officials of the local post office, which was perhaps in the neighborhood of Ptolemais, were the two brothers Phœnix, who were known also under the sobriquet of "hundred-acre men"; that is, they were colonists of the really prosperous class. The service they were rendering in the post office was an office of honor that had been conferred on them. That a salary was allotted to Phanias, the postal clerk, is one of the entries in the diary, but the amount of it is not mentioned; and that the diary was written on a papyrus of which the far greater part had already been used, shows that the brothers had proposed to conduct their office economically.

STANDARD CLOCKS OPERATED BY WIRELESS.

VIENNA'S SOLUTION OF AN INTERESTING PROBLEM.

BY DR. ALFRED GRADENWITZ.

The necessity of a reliable system of standard clocks controlled from some central station for the use of private and public offices, for squares, railway stations, and even for the purposes of private parties, is being more and more keenly felt, especially in larger towns and industrial districts. In fact, the increasing difficulties in the conditions of life and existence are calling for a most perfect utilization of time—the only capital at the disposal of most men. The installation of a satisfactory system of central clocks thus becomes a social problem to be solved by every large community.

It is true that many endeavors have been made for some decades past to design suitable combinations of mechanical and electrical systems without, however, finding a solution fit for all cases. While some individual successes within rather limited ranges have been obtained from time to time, none of the systems so far suggested allowed any extensive district, or even modern capital, to be equipped with a system of efficient electrical central clocks.

The reasons of this failure are of both a technical and a financial nature. On the one hand, there is the necessity of using cable conductors, which are so difficult and expensive to lay out and so easy to disturb, and on the other hand, the prohibitory cost of a cable system used exclusively for clock operation and which, accordingly, is dead during most of the time, being hardly profitable even in the case of a high subscription fee. Now the success of any central plant of this kind just depends on the moderateness of this fee.

Furthermore, the increasing decentralization of modern cities results in the residential districts, especially of the wealthier classes, being advanced ever farther into the rural surroundings, where the necessity of an accurate timekeeper, owing to the frequent use of various means of communication, becomes especially urgent. Now, the laying out of a cable 10 to 20 kilometers (6.21 to 12.43 miles) in length exclusively for the sake of a standard clock system is obviously quite unfeasible, even in the case of a large number of subscribers.

The city of Vienna, Austria, has shown the way toward a satisfactory solution of this problem by adopting a scheme of wireless operation for an extensive standard clock system. When, in 1904, a cable system was about to be installed, Franz Morawetz, a court watchmaker, suggested the use of electric waves, as utilized in wireless telegraphy, for the operation of central clocks. The municipality soon discarded its original project, and induced Morawetz immediately to commence his tests of the system proposed in conjunction with Dr. Max Reithoffer, professor at the Imperial and Royal Electrical Institute. This institute was to serve as the central station. The expenses entailed by these tests, apart from a subvention granted by the municipality, had to be borne by the two experimenters.

The work progressed steadily though slowly, enormous difficulties having to be surmounted. The possibilities of transmitting electric waves over blocks of houses were soon ascertained, and the most advantageous wave length fixed. The chronometrical part of the problem could then be commenced, and this occupied the greater part of the time, the definite design of each constructive part having to be ascertained by actual practice, though the original programme was found to be correct in all its details.

Permanent trial operation during day and night was then inaugurated in the summer of 1908, the results being so favorable that official checking tests by the Municipal Building Offices were begun the 1st of December and completed by the 1st of April, with a success so splendid that the reliability and practical possibilities of the system were brought out beyond any doubt.

In the following will be given a short description of the system developed by the experimenters:

An electrical pendulum (boxed in and the parts enlarged in Fig. 2) with an absolutely non-oxidizable contact closes every second the current for operating the checking clock, and the wave switch, Fig. 3, which every minute completes during two seconds an alternate current of 110 volts 15 amperes for feeding the induction coil. The electrical vibrations given out by the coil are radiated into space from a horizontal antenna, stretched out between two iron poles 19 meters (62.3 feet) in height, placed on the roof. Fig. 4 represents this induction coil and remaining high-tension apparatus, and Fig. 5 the experimental receiving station at Breitensee, placed at 7 kilometers (4.35 miles) from the central station. This comprises an inclined antenna with poles 10 meters (32.8 feet) in height. Fig. 6 gives an inside view of this experimental station.

On arriving at this experimental station, the electric waves caught by the antenna are made to traverse a system of inductive coils making the coherer conductive and closing the local circuit of a special relay, which in turn actuates a more substantial relay. The latter, Fig. 7, then works the most important apparatus of the whole system, which is intended to eliminate any disturbance due to foreign waves or atmospheric discharges.

A simple pendulum of the same construction as that of the central station causes a wheel to advance through 60 teeth every minute. At the 59th second, the apparatus is made ready to receive the chronometrical wave, and as this arrives the clockwork is disengaged and the wheel runs back under the action of a weight while any further communication with the wave receiver is discontinued. It will be under-

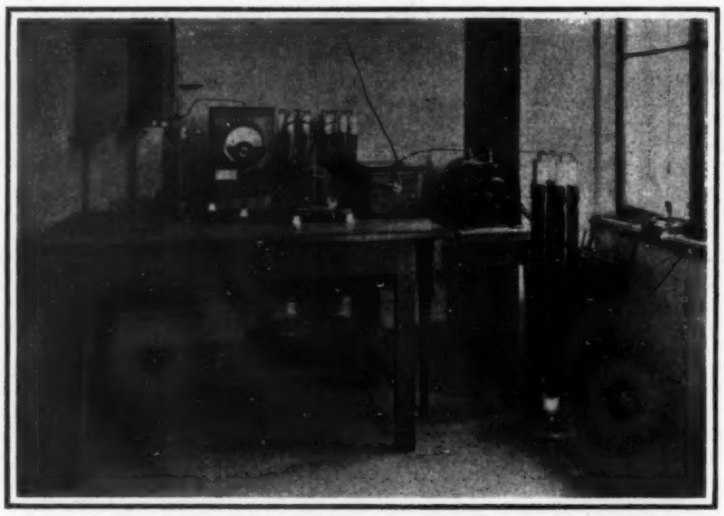


Fig. 4.—THE INDUCTION COIL AND HIGH-TENSION APPARATUS.

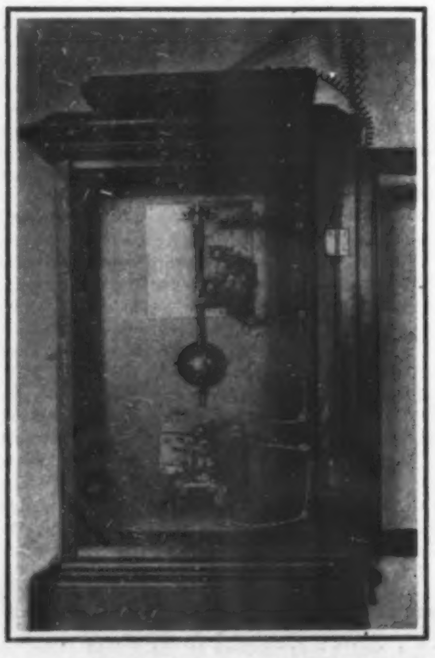


Fig. 1.—AN ELECTRICAL PENDULUM AND CONTACT FOR WIRELESSLY OPERATED CLOCKS.

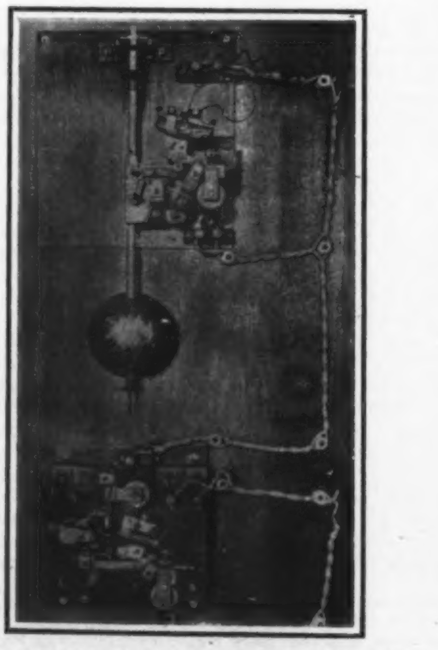


Fig. 2.—THE PENDULUM AND CONTACT FOR OPERATING THE CHECKING CLOCK (ENLARGED).

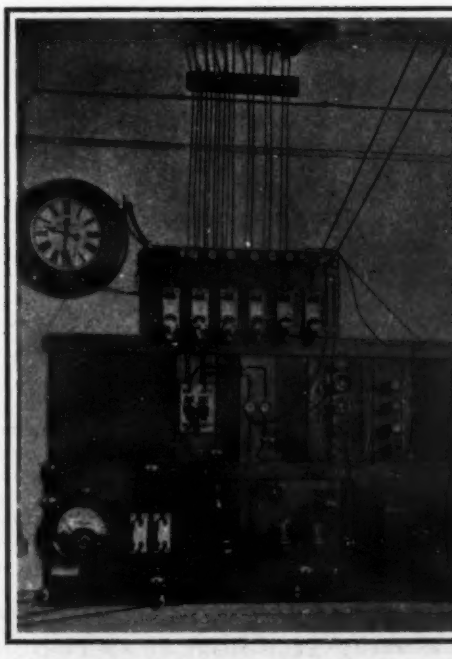


Fig. 3.—THE WAVE SWITCH WHICH COMPLETES THE ALTERNATING CURRENT CIRCUIT.

stood that any foreign signals now arriving would pass unnoted, the more so as the antenna during this time is disconnected. If, however, those signals arrive at the moment the apparatus is ready to receive the clock signal, they will when repeated frequently result in a slight advance in the working of the clocks, which difference, however, can readily be compensated by controlling the pendulum as soon as the disturbance has disappeared.

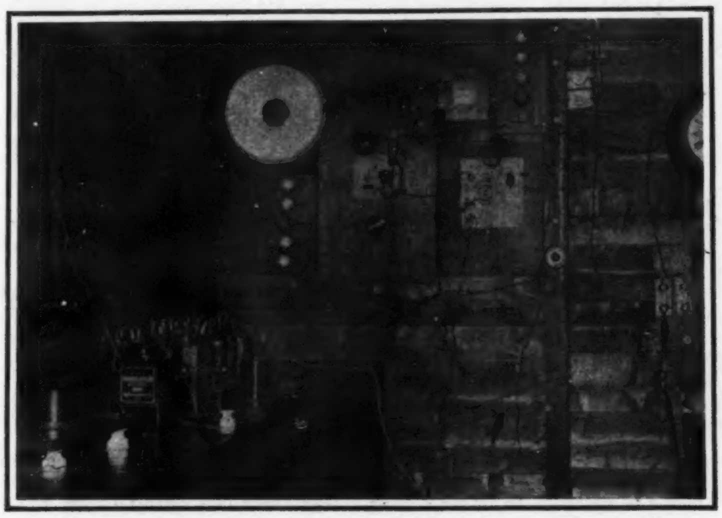


FIG. 6.—THE INSIDE VIEW OF THE EXPERIMENTAL STATION.

It would be too long here to describe the remaining auxiliary apparatus. All the parts of the construction are designed for automatical operation, and have worked with excellent results throughout the tests.

As the electric waves are transmitted uniformly in all directions, while their range is only dependent on the amount of energy available, an extensive district could obviously be comprised within the wireless clock operation, while the plant could be continually extended without any decrease in the safety of operation.

The secondary clocks constructed especially for the present apparatus are worked by continuous currents, and are connected in a circuit in groups of twenty-five each. As each circuit has its own contact, which is disengaged from the controlling apparatus, a given receiving station can be connected with an unlimited number of secondary clocks of any size, these clocks communicating with the substation by aerial conductors. In choosing the locations of the substations, the position of tramway lines should be taken into account, each block surrounded by tramways having its own receiving station.

Fifty receiving stations, with a capacity of 4,000 subscribers' clocks, 2,000 municipal clocks, and 300 public clocks, are so far being designed for the city of Vienna. With a fee of two kronen per clock and month, this plant would yield a net benefit of 10.3 per cent, the operation of municipal clocks being free of charge. The community of Vienna shortly intends to increase the system to a radius of 150 kilometers (93.2 miles), the central station being built with this object in view.

THE SCRAP HEAP.

THERE is a familiar story of an illustrious engineer who, when visiting some mechanical engineering works, was asked what he would like to see first. His reply was, "the scrap heap"; and the story goes on to add that he found so much of interest there that he never saw the shops at all. There is also a story less well known, perhaps, of another engineer who, emulating his great predecessor, asked an American engine builder the same favor. "Pray, pardon us," was the reply, "we keep the secret of our success to ourselves." Both stories illustrate admirably the fact that mechanical engineering has been thrashed out by step-by-step progress. Failures have taught men what to avoid, and the scrap heap is nothing but the living and speaking note-book of experiments. Every broken or futile part is a post labeled danger, and the multiplication of such posts on both sides of the road buoy out a passage along which the engineer may travel safely. It has often been suggested that some of our learned societies should persuade the authors of papers to give histories of failures instead of successes. Rarely, indeed, do we get anything of the kind; and if it were not for the reports of the chief engineers of insurance companies and official returns, we should all be left in the dark as to the causes of failures. Among the former the report of the chief engineer to the British Engine, Boiler, and Electrical Insurance Company is one of those most eagerly read, and it is its appearance that has suggested these remarks.

Mr. Longridge provides us annually, first with a general review of the accidents of recent years, and then with details of a number of cases selected from the accidents of the last twelve months. It may be taken, we imagine, with safety, that his records represent in miniature the whole country, and it will be fair to assume that the percentages of failure he gives are fair percentages for the machinery generally of the United Kingdom. Now, in 1907, of all steam engines insured 1 in 11.7 suffered some accident, and of all gas engines 1 in 11.1. In 1908 the proportion had risen respectively to 1 in 9.4 and 1 in 9.1. Mr. Longridge neither offers any explanation of this increase as a whole nor of

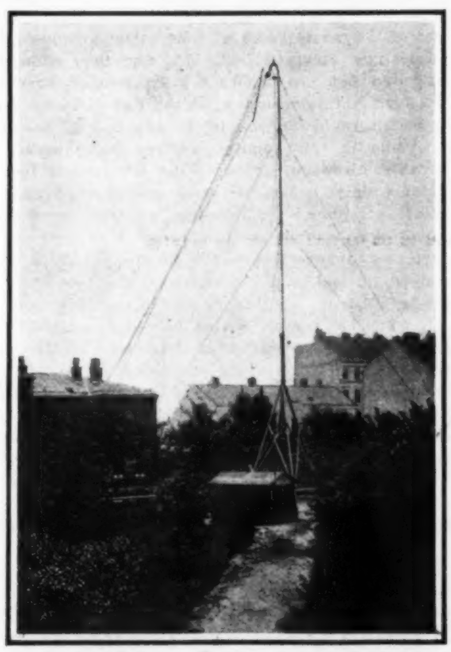


FIG. 5.—THE EXPERIMENTAL RECEIVING STATION AT BREITENSEE.

the remarkable fact that both types of engine have advanced by almost equal amounts. It may be purely a coincidence, but it is sufficiently curious to be worthy of observation. When we turn to the details of breakdowns we find also some curious facts. For example, in steam, gas, and oil engines the valve gear is the part most liable to failure; but whereas the percentage of such failures in steam engines has risen from 28 in 1907 to 34.8, in internal combustion engines it has fallen from 43.3 to 31.3. These percentages are based on the total number of breakdowns, and as we do not know the numbers, it is difficult to say whether the proportion is fortuitous or not. Mr. Longridge, however, remarks, "The continually increasing percentage of breakdowns of steam engines, due to breakage of valves and valve gear, from 23.3 per cent in 1906 to 28 per cent in 1907 and to 34.8 per cent in 1908, suggests that some improvement in designing and manufacturing these parts is desirable. Perhaps more strength, and certainly more care in fitting and screwing nuts, screws, pins, and cotters, would reduce the figure." This observation reflects, we fancy, rather on the user than on the maker, for we find on the examination of the few cases that are given in detail that the failure of new, or even fairly new engines, is comparatively rare. It is generally an engine some years old, frequently many years, that fails, owing to the cumulative failure—if we may so call it—of some part, or the negligence of the attendant. The increase in one case, and the decrease in the other, of the percentage of failures in valve gear must naturally affect the proportion which the failure of other parts bears to the whole. Among steam engines nearly everything else has decreased by a small amount, and some by large amounts, but here any definite deduction is impossible, because in some cases the decrease is obviously due to the fact that the part that used to fail is disappearing altogether. For example, failures of spur gearing showed an average of 14.8 for the twenty years preceding 1907, and in 1908 it had fallen to 8.1, largely, as Mr. Longridge remarks, because spur gearing is rapidly disappearing from engine rooms of textile mills and factories. A similar remark can, of course, be made of the various parts of beam engines, which are being gradually replaced by modern types. Gas engines, of course, are all more or less modern, and since the same argument cannot be applied, the comparative figures are of more value, and it is a little disconcerting to find that the four principal parts have all shown percentages of failure greater than for last year. Failures of cylinders and cylinder ends have risen from 13.5 to 19.4, or 2.8 above the general average; of pistons from 2.7 to 4.8, but in this case the reduction on the average is great; of connecting rods and their bolts the rise is from 8.1 to 10.8, and of failures of main shafts the increase is from 4.7 to 9.1. This, again, is a long way above the average, which is only 5 per cent, and would indicate that further attention to this part, which has always presented difficulties, is required. Mr. Longridge, in view of certain tests on crank webs, urges the desirability of employing built-up cranks whenever possible; and there is really no valid objection to that plan being adopted, since the processes of manufacture have been so perfected that the building up of a crank presents but little difficulty. We shall on another occasion refer in more detail to one or two of the principal engine breakdowns, and in particular to a remarkable failure of a shaft to which the report devotes a good deal of space.

We turn now to electrical machinery, and notice that here also the number of breakdowns has increased. Among dynamos there has been an increase in the number of failures of no less than 13 per cent over last year, among motors of 8.2 per cent, and among starters and controllers 18.2 per cent, the overall increase being no less than 10.7 per cent greater than in 1907. At first sight one might be disposed to regard this as indicating that electrical engineers were slow to learn the lesson of the scrap heap, but Mr. Longridge has attempted a classification of the causes of failure, and we observe with satisfaction that they indicate that if there is not a marked improvement in construction, there is at least no retrogression. In 1907, 21 per cent of the failures of dynamos were ascribed to bad workmanship and design; last year only 20 per cent of the failures were attributed to this cause. In 1907, 18 per cent of motor failures were due to the makers; in 1908 only 11 per cent; but for the breakdown of start-

FIG. 7.—THE APPARATUS WHICH ELIMINATES DISTURBANCE DUE TO FOREIGN WAVES.

ers and controllers the makers' responsibility has risen from 8 per cent to 9 per cent. Dirt and neglect are held to be the cause of something over one-quarter of the failures of dynamos and motors, and age and deterioration account for nearly as much. Hence, we find that half the accidents are due to causes directly preventable by the user, an amount which is 10 per cent higher than among steam engines, and 13 per cent higher than among internal-combustion engines. In all cases the percentage is higher than it ought to be, and the need which we have so often urged of employing properly trained persons to look after machinery, is enforced by a consideration of the figures. When we turn to Mr. Longridge's review of boiler failures during the year—none of the boilers insured by the company have failed—we find the same convincing fact that it is the user of the boiler who in the majority of cases is responsible for the accident. Of fourteen boiler explosions on which formal investigations were held in 1908 by the commissioners, penalties were inflicted in eight cases. It is clear that many breakdowns of all sorts of machinery could therefore be prevented if only proper care and attention were used. To prevent accidents altogether is humanly impossible, but it should be possible to add very materially to the number which must be included under the head of unascertained causes. At the present time the makers are battling with two opponents. They have, on one hand, the so-called "mysterious" failures of material, and, on the other hand, the crass folly of many users. They are overcoming one by diligent research and experiment, and the others by a heartbreaking effort to make things fool-proof. That the latter might be materially facilitated by the collaboration of the user is not a matter about which there can be dispute.—The Engineer.

THE INTERNAL-COMBUSTION ENGINE.—III.*

RECENT IMPROVEMENTS.

BY H. E. WIMPERIS.

Concluded from Supplement No. 1763, page 247.

We have now to consider the way in which the recent great practical improvements in the design and operation of gas engines and gas-producing plant have come about, and how they are connected with the theoretical considerations referred to in the previous articles.

Despite the multitudinous ways in which the internal-combustion engine is employed, there is a general assortment into three main groups, which may be described thus:

(a) Large gas engines for gas blowing, for the generation of electric power or other power purposes, the size being usually more than 1,000 horse-power.

(b) Smaller gas or oil engines used for workshop driving, in sizes up to about 500 horse-power.

(c) Gasoline engines for road transport, for marine work, and for aeroplanes, the sizes being usually less than 100 horse-power.

With class (a) are associated pressure gas producers, frequently worked with by-product recovery plant, and schemes for the utilization of the waste gases of coke ovens and blast furnaces. The gas engines in class (b) usually derive their gas from suction gas producers, which are practically always of smaller size than the 500-horse-power unit, though attempts are now being made to work with the larger units suitable to marine work. H. M. S. "Rattler" is one of the very first instances of the application of the suction gas producer to marine purposes, and it has been remarkably successful. Looming in the distance is the prospect of using suction gas producers and gas engines in smaller units for road transport, but the difficulty of finding space on the present type of motor car for the whole of the plant is a great one. On the other hand, the considerable economy in fuel to which this development would lead is an inducement to proceed with the endeavor to overcome these difficulties.

By far the most numerous class of internal-combustion engine is that of class (c), which includes the thousands of motor cars and cycles now in use in all civilized countries. The fuel used is not invariably gasoline, as successful attempts have been made to run on alcohol, benzol, and the heavier elements in the kerosene series. Ordinary commercial kerosene has recently been used with extraordinary success, particularly in tropical countries, and it is even reported from Uganda that the combination there of altitude with high temperature enables kerosene to be used as a fuel in small engines without any change in the usual gasoline carburetor as used in this country.

IMPROVEMENTS IN CLASS (A).

The chief direct practical improvements in this class are the better proportioning of parts, so as to avoid cracking by unequal heating, and the better general design of the fly-wheel effect in conjunction with such an arrangement of cylinders as to produce a more even turning moment, and therefore less cyclic irregularity. The former is evidenced by the greater trustworthiness to-day of the big engine, and the latter is abundantly illustrated by the following extract from Messrs. Andrews and Porter's recent paper† before the Institution of Electrical Engineers:

"The large gas engines at the Bruckhauser, Homecomb and Heinitz installations visited by English engineers in August last are all provided with fly-wheels to maintain a cyclic irregularity within 1/250. The two former are single tandem engines, and the latter twin tandem, but no appreciable difference in the parallel running was noticeable."

The information derived from recent experimental work on piston and wall temperatures will probably lead to still further improvements in the mechanical design of details, as once the conditions of the heat flow are known a proper proportioning and subdivision of parts is rendered possible. The recent improved trustworthiness of operation is shared equally by the two-cycle engines (such as the Oechelhauser, Koerting, and others) and the four-cycle engines, and it is very difficult to say that either type is gaining ground at the expense of the other. By-product recovery work is becoming better understood, although there is always the difficulty that the by-products, when produced, have to be sold, and one has therefore to take into account the effect upon the market price should a largely increased output result from the extended use of such plant. The utilization in gas engines of the waste gases of coke ovens, and blast furnaces is now very usual. This is especially so in Germany and Belgium, where a great deal of work has been done in this direction; in the United States there has been a rapid increase in the adoption of this process, while in this country matters have moved appreciably, although, owing to the low cost of fuel in England, there is not the same economic pressure to make the change. On Tyneside, an excellent plan is in operation, whereby engines running on waste gases are made to generate electric power, which is then supplied to, and paid for by, the central electric generating station. By this method of pooling the current, which, of course, cannot be economically stored, but has to be used as fast as it is produced, the complicated questions as to its utilization are avoided.

A notable recent improvement in the ignition of gas engines of all sizes is the adoption of the electric system with either low-tension or high-tension currents. On the whole it seems likely that, as with motor cars, the latter will in the end become the most used, though at present the low-tension system with moving contacts inside the cylinder seems to be the most popular.

IMPROVEMENTS IN CLASS (B).

In both this class and class (a) it is noticeable that the engines designed on the Continent are more complicated in appearance than those designed here. The British desire for simplicity doubtless is, at the root, a good one. One of its most noticeable illustrations in modern life is the steam railway locomotive. As applied to the gas engine, this desire takes effect in the much simpler method of governing. The usual English plan is to govern on the "hit-and-miss" principle, that is to say, when the engine runs up to too fast a speed the cylinder for one or more cycles will get no charge of gas at all, or else (which comes to the same thing) the ignition will be cut off and no explosion take place (this, though a very simple means of governing, is wasteful in fuel). The average Continental design provides for the throttling (as in a steam engine or by varying the lift of the inlet valves) of the entering charge, so as to cause a less intense explosion. This tends toward a steadier speed, but on the other hand leads to a constant lowering of the compression ratio, and therefore to a diminished thermal efficiency and an increased rate of fuel consumption.* In England the difficulty of speed fluctuation, to which the adoption of the hit-and-miss principle leads, is met by increased fly-wheel effect or by dividing the power between a number of cylinders, but several well-known English makers are now governing by throttling the mixture.

The standard of achieved thermal efficiency is continually rising, although the amount of the improvement is the less easy to state on account of the very optimistic way in which certain experimental readings seem to have been taken. Much depends upon the ratio of compression, and many attempts have been made to permit of a high compression pressure without pre-ignition. This has been successfully attempted in several ways, viz., by the method of water injection, so lowering the compression temperature corresponding to a given pressure, or else by the method of supercompression, which consists of causing the incoming charge to be at a pressure of from 5 pounds to 10 pounds above the atmosphere, so that here also a higher pressure corresponds to a lower temperature, and sometimes by the method of decreasing the proportion of hydrogen present, and so raising the temperature at which the mixture would be liable to pre-ignition. In the usual form of suction producer, the proportion of hydrogen present is usually about 20 per cent, and a method of lowering the amount which has been employed recently is to admit exhaust gases into the producer in place of the usual water supply. The CO_2 then takes the place of H_2O as an energy absorber, and the chemical composition of the resulting gas is so greatly affected that the hydrogen sinks to less than 1 per cent. Another recent improvement in the suction gas producer is the regulation of the water admitted, so that the composition of the gas may be the same, no matter whether the "draw" of the engine is vigorous or slight. Without some such device the gas tends to become "wet" at the lower loads, and the producer to "go dead." To avoid this, the water supply to the producer has to be cut off, or greatly reduced, in proportion as the governor is cutting out working strokes in the engine.

IMPROVEMENTS IN CLASS (C).

These are exceedingly numerous. The most recent decided change has been the adoption of the sleeve type of valve in the Daimler engine. Despite apparent drawbacks from the theoretical point of view, it has lately undergone an extremely severe test under the officials of the Royal Automobile Club, and has emerged victorious. It is understood that a number of other manufacturers are now considering the adoption of the slide type of valve.

Another innovation is the use of air pressure to force the fuel up from low-lying tanks to the carburetor. This is claimed to be an improvement on the exhaust pressure feed, as being less likely to choke. As regards heavy oil engines, the chief improvement to be noticed is the wide-spread use of water injection, which is even more useful here than in a gas engine on account of the very low pre-ignition point of mixtures of oil vapor and air.

Attempts have continually been made to produce an engine working on the two-cycle principle, and there would seem to be no reason why engines of this kind should not be as practically successful as any built to operate on the four-cycle principle. One would expect that in this way a lighter engine could be built, and lightness is a great asset, particularly in the most recent use to which the internal-combustion engine has been put, viz., aeroplane work. Wonderfully light engines have already been made for this purpose. The 50-horse-power engine on the aeroplane "Silver Dart" weighs only 220 pounds without oil and water, or 4.4 pounds per horse-power. The 50-horse-power "Wolseley" V-type eight-cylinder engine, built for aeroplane work, is reported to weigh only 340 pounds, or 6.8 pounds per horse-power, although the engine is fitted with a water-cooling system. The somewhat similar 80-horse-power engine fitted to Mr. Moore Brabazon's aeroplane is reported to weigh only 366 pounds, or 4.6 pounds per horse-power; this is also a water-cooled engine. The possibilities of the different types of engines have lately been summarized in the technical press* in the table.

From this it appears that engines amply light enough for aeroplane work have already been built, and there is not much scope left for any improvement in this direction for which the two-cycle engine would

* Nature.

† "The Use of Large Gas Engines for Generating Electric Power," Read before the Institution of Electrical Engineers, 1909.

* In a specific case the reduction of the compression pressure from 170 lbs. to 120 lbs. led to an increase in the thermal units used per horse-power from 9,500 to 11,500.

* Engineering, April 16

be useful, although there is still room for general improvement by the avoidance of the use in the engine parts of all heavy materials of low mechanical strength. On the other hand, the lighter the engine the better, as it means the possibility of adding additional accessories that make for constancy of opera-

Type of Engine.	Weight per Brake Horse-Power. Lbs.	Weight of 50-Brake Horse-Power Engine. Lbs.
Four-cylinder vertical......	8	400
Eight-cylinder diagonal....	6	300
Diagonal, with several cylinders grouped on one crank pin	4	200
Rotary	3	150

tion, such as duplicate ignition, ample water-cooling arrangements, etc. The aeroplane appears to offer little chance of an "altitude stop" to permit of the engine being adjusted, and constancy of operation is therefore the one essential thing so far as the motor is concerned.

Carburetors are continually being improved, but the ideal one, which will give a constant mixture at all speeds and all loads in all weather conditions, has yet to be invented. The high-water mark as regards fuel economy that has so far been reached is the performance of the White and Poppe carburetor in the 1907 Royal Automobile Club trials of commercial vehicles. This carburetor was fitted to a Maudslay car, and showed the very high "figure of merit" of 62 gross ton miles per gallon of gasoline, which is nearly twice as good as was obtained from the average car of that time. In the last two years the average has, however, risen appreciably. This, with an assumed road resistance of 50 pounds per ton, would correspond to an efficiency of power transmission between the carburetor and the road wheels of no less than 15 per cent. What the road resistance really was is not known, but now, without doubt, such road resistances ought to be accurately measured and the results applied.

CONCLUSION.

With such a rapidly moving industry as that of the internal-combustion engine, prophecy is even more unsafe than it usually is. Writers have been bold enough to look forward to solid explosives being employed, but there one is faced with the difficulty of selecting any form of solid explosive that would have an entirely gaseous exhaust. When the gas turbine has taken practical shape, this consideration may be of less importance. Indeed, the combination of a solid explosive with a gas turbine promises this advantage, that the difficulty of the initial compression would thereby be removed. On the other hand, if we may judge by analogy with the steam turbine, provided that it were possible to keep the exhaust pressure sufficiently low, a high initial pressure would not be essential to economy. Whatever may be the outcome of the present experiments with gas turbines, or of gas producers, suitable for marine purposes on the one hand or to road transport on the other, one may be certain that the days of the external-combustion engine, the steam engine, are numbered, and that the engineers of the near future will not be satisfied with any less degree of efficiency than that which the internal-combustion engine will afford. One seems to see in the world of engineering the working of a continuous process leading to the suppression of those ideas, which, though old and tried friends, are found to produce less efficient results than those obtainable by more scientific methods. There is no reason that the writer can see to doubt the continued operation of this process during the present rivalry between the steam engine and the internal-combustion engine.

A PRACTICAL TELEPHONE.

SUGGESTIONS FOR THE USE OF A HOME-MADE TELEPHONE.

BY FRED W. LANE.

The purpose of this article is not to tell how to make an electric bell or any other requisite for a telephone; so many good pamphlets have been written on these subjects that anything I might add would be superfluous. Many amateurs, I am sure, have made much of the apparatus needed for this telephone. They only await some suggestion as to how they can put it to the best use. I shall endeavor to give plain directions for setting up a telephone line which will be of real value if connected with your friend. Having set up and used one of these telephones for over a year, I can vouch for its efficiency.

The Outfit.—Complete outfit for two stations consists of the following. If you do not care to make your own apparatus the prices set down may be of value:

Two pounds No. 16 wire..	$0.35 per pound	$0.70
Four dry cells...........	.25 each	1.00
Two mahogany boards...	.20 each	.40
Two push buttons........	.10 each	.20
Two buzzers	.25 each	.50
Two 3-point switches.....	.25 each	.50
Four-foot incandescent lamp cord	.02 foot	.08
Two receivers	1.00 each	2.00
Two hooks	.10 each	.20
Screws, staples, tape, etc.		.10
Total		$5.68

The above list gives the cost of A1 material. Of course the amount of wire to be bought will be governed by the length of the line. Each pound of wire (No. 16) contains about 150 feet. If sal ammoniac liquid cells are preferred, the price will be about 45 cents each. The cheaper boards may of course be substituted for mahogany ones; the switches may be bought as cheaply as 10 cents each, if necessary. You can buy the boards in the rough, and shape, sandpaper, and apply a little filler yourself.

Setting Up.—Fig. 3 shows the electrical connections; Fig. 1 is a suggestion for setting the apparatus on the board. Outside, the wires may be fastened at each terminal to picture knobs screwed to the sills of second-story windows. Instead of running the wires into the house under the window frame, thereby crushing them whenever the window is raised or lowered, run them in just below the clapboards. A neat way to do the wiring is shown in Fig. 2. On the inside, use small staples to fasten the wire, but do not put the two lines of wire under the same staple—run each line separately. To fasten the board to the wall, screws about 2¼ inches long will be needed. In order to leave room for wiring on back of board, make two wooden washers by cutting pieces about ¼ inch thick from a brush or broom handle and drilling holes the size of the screws through them. The manner in which the different parts are to be connected will be readily understood by consulting Fig. 3. Run the wire to the receiver from under the board at *A* (Fig. 1). If you fasten the board to the wall with one edge against a door casing, the wires may be made very inconspicuous by running them up the side of this casing to the board. By following Fig. 3, anyone should be able to set up and operate this telephone. Only general carelessness, such as loose connections, should cause trouble. Great care should be taken to see that the batteries of the two stations are so connected that they will not work "against" each other. That is, the carbon plate of the battery at station A should be connected with the zinc plate at station B. (See Fig. 3.)

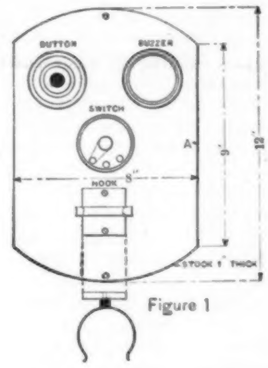


Figure 1


Figure 2

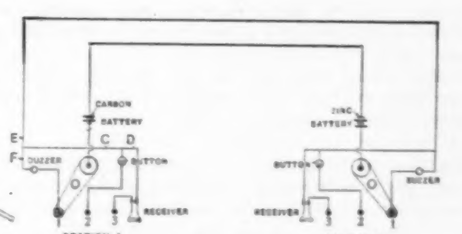


Figure 3

INSTALLATION OF A PRACTICAL TELEPHONE.

as the working of the receivers goes. However, in my telephone I used the cells on the main line, and will give it to readers in the same way. If at times the voice of the person with whom you are speaking seems far off and indistinct, but at others loud and clear, see if the screw in the end of your receiver (if the instrument is built in this way) is tightly in place. This defect caused me much extra work, and it was only after going over the whole system several times that I discovered the cause of the trouble. Of course it must be seen that the single receiver at each end must be used on both as a mouth and ear piece. It may seem, too, that to use the plain board with the switch occasions much more inconvenience than would be presented if the current were governed by a receiver hook. Perhaps this is so, but after using my telephone a few days I found that it was very easy to turn the switch and use the same instrument both for mouth and ear piece. And as regards neatness in appearance, this instrument is a fitting supplement to the best room in the house.—Electrician and Mechanic.

How It Works.—In Fig. 3, *O* represents the levers of the switches; 1, 2, 3 represent the other points. The lever must always rest on point 1 when the telephone is not in use. When station A wishes to call station B, the lever *O* is moved to point 2 and the button pressed. In this ringing, the current starts at the battery at station A, let us say, and flows down through *O*, point 2, and the button. It cannot flow out through *D* and the receiver, for the circuit is broken at point 3. Its only course is to follow wire *C*. The current cannot flow by wire *F* and the buzzer, for, at the time of ringing, the lever *O* is on point 2, so the circuit is broken at point 1. The only way it can find a circuit is by following wire *E* to the other instrument. At station B it flows through the buzzer (point 1), through *O*, the battery, and back to the point of starting. Had the lever *O* not been on point 1, station A would have been unable to call station B. This is why the lever must rest on points 1.

When station A has rung, the lever *O* is pushed on to point 3. In answering, station B pushes *O* immediately on to point 3, not stopping at 2. With both levers on the points 3, one can see at a glance that the receivers are now a part of the circuit and the stations may converse. Therefore, when telephones are not in use, the levers should rest on points 1; to call, push lever to point 2 and press button; to converse, both levers must be on points 3. By studying Fig. 3 a little and applying a test similar to that given above, you will be able to see why the current flows in a manner to produce the required operations, instead of by some other wire. The one thing that must be remembered in doing this is that the electric current must have a circuit around which to flow. By following this principle, plans to produce any required action are formed. The batteries are needed for ringing purposes only, and could be dispensed with as far

Volt scales for indicating the voltages to produce a desired candle-power have been used on photometers in many glow-lamp factories, as the public demand only a few candle-powers, but considerable latitude in the voltage. It would be extremely convenient to be able to ascertain the voltage required to produce the correct watts per candle by a direct reading, and if possible the corresponding watts or candle-power at the same time. A volt scale meter, described in the Electrical World, accomplishes this object. A watts-per-candle or "specific consumption" meter, designed by Hyde and Brooks, is part of the photometric equipment of the Bureau of Standards. Tables are calculated so as to reduce the labor required to find the "3.1-watt" voltage. The author of the article referred to diminishes this labor by using a volt scale on which the data given in the tables are indicated at once. It is shown how to combine a volt scale and a watts-per-candle meter so as to be able to read from one setting (1) the voltage to give a certain specific consumption, and (2) the candle-power or watts at that voltage.

AN ARMORED CONCRETE VIADUCT.

ROTTERDAM'S REMARKABLE GRADE CROSSINGS.

BY C. VAN LANGENDOUCK.

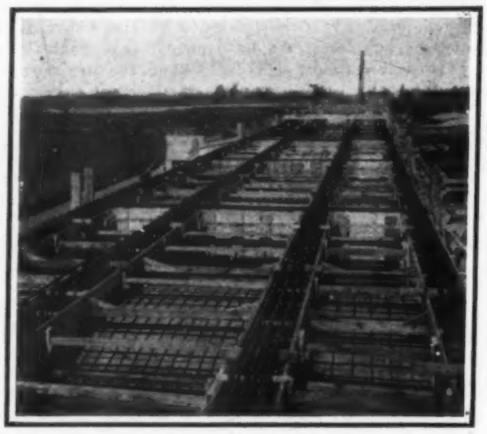
IN 1900 the Dutch government authorized an electric railway company to construct a line from a central point in Rotterdam to Scheveningen, with a branch to The Hague. The authorities of Rotterdam stipulated that the road, within the city limits, should be placed on an elevated viaduct, so constructed that it would not interfere with street traffic, and the general government stipulated that an intersecting steam railway should be crossed on a viaduct. As the railway crossing is only 3,000 feet from the end of the city section, it was decided to continue the viaduct to the crossing. The length of the city section is about 2,300 feet, so that the total length of the viaduct is a little more than one mile.

The construction of a masonry viaduct would have entailed great expense, especially in the laying of the numerous and massive foundations, and an iron viaduct was also considered too costly. Hence, in view of the very satisfactory results which had been obtained elsewhere with armored concrete, it was decided to use this material.

The construction of the foundations was commenced in 1904, before the character of the superstructure had been determined. The system employed for the city sections comprises ordinary connected foundations for the piers with continuous piling between them. The length of the piles is from 52 to 66 feet beneath street crossings and from 46 to 52 feet beneath the normal spans of about 26 feet. These piles support 8 x 12-inch beams, 6 x 8-inch cross beams, and 3-inch flooring. Under the normal spans the upper surface of the floor is 9.3 feet below mean water level, but at street crossings it is placed 13.4 feet below that level, in order to avoid disturbing water and other pipes. The piers rest on this plank floor, which is covered with a bed of non-armored concrete the upper surface of which is 6 feet below mean water level, or 2.7 feet below the street level. In the section outside of the city the armored concrete superstructure rests directly on piles.

The superstructure of the city section, exclusive of the terminus and yard, comprises 63 normal spans, with 58 piers, and 6 street crossings, with 1 small and 12 large piers. The single span crossings vary in length from 33 to 71 feet. The longest crossing, 88.6 feet, has a middle pier. The piers which support the normal spans are 25.6 inches thick; the thickness of the bridge piers varies from 8.2 feet to 17.5 feet, according to the length of the crossing.

Each of the piers of the normal spans is composed of 4 rectangular columns of armored concrete, 18 feet high, 15.7 inches wide, and 25.6 inches thick, connected together by two walls, 3 inches thick, and by a common base of armored concrete, which distributes the weight over a large surface of the plain concrete foundation. Each column, with the corresponding column of the next pier, supports an arched girder 12 inches wide, 57 inches deep at the ends, and 18 inches deep in the middle. Each girder lies vertically under a rail of the double track. The concave lower surfaces of the four girders of the span are connected together by a sheet of armored concrete, 3 inches thick, which is jointed to the walls which flank the columns. The flat upper surfaces of the girders are connected by a concrete floor, of an average thickness of 5 inches, which supports the ballast and track.



VIEW OF THE TOP OF THE VIADUCT WITHOUT THE UPPER FLOOR AND ROADBED.

This floor is constructed by first laying concrete tiles 1.6 inches thick, which are just strong enough to support the rest of the concrete until it sets. The arch below stiffens the structure, and the air inclosed between it, the floor, and the walls diminishes the effect of variations of temperature and also lessens the noise produced by the passage of trains. Thus the spaces beneath the spans are made available for use as warehouses, of which several have already been constructed and leased.

On each side, the floor overhangs the exterior girders by 30 inches and carries a raised footway 35 inches wide. The trough, 22 feet wide and 14 inches deep, which is bounded by the footways, is filled with crushed stone in which the wooden cross-ties are imbedded. The ties are 6 inches deep, and consequently rest upon an 8-inch stratum of ballast.

The street crossings are constructed on the same plan as the normal spans, but more massively. The arched girders, though they have the same width and the same depth at the middle as the shorter girders of the normal spans, are 96 inches deep at the ends. This increase in the depth of the girders necessitates the employment of iron cross-ties, in order to maintain the depth of ballast beneath the ties at 8 inches.

Each pier of a street crossing is composed of four longitudinal 16-inch walls, connected by two transverse walls of the same thickness and by a base 14 inches thick, which equalizes the pressure on the plain concrete foundation. In order to equalize the pressures on the four walls, they are connected, at the top, by a floor of armored concrete. The voids between the walls are filled with a weak, non-armored concrete, which by its weight increases the stability of the structure.

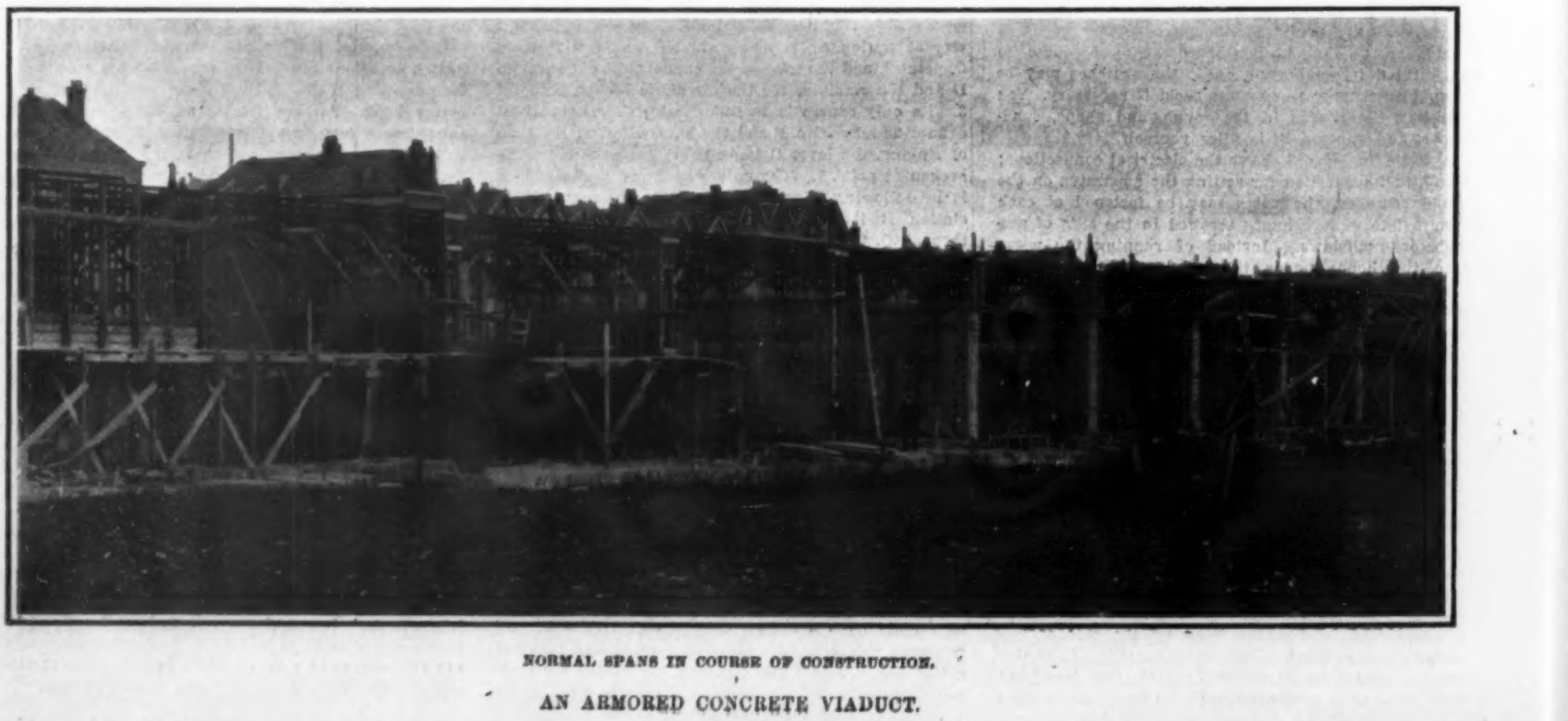
The reinforcement of most of this city section of the viaduct consists of round, flat, L-shaped, and T-shaped bars, so combined that the profiled bars form an independent structure. The inner end of the section is gradually expanded to a width of 150 feet, to form a terminus and shunting yard. In this part of the viaduct the irregular distribution of the tracks made it necessary to change the method of construction. Here the roadbed rests upon an assemblage of arches, each 8 inches thick in the middle and 12 inches thick at the edges.

The arches rest on armored concrete beams, 24 by 32 inches in section, and the beams are supported by columns about 8 feet high, measuring 16 by 32 inches at the top and 16 by 45 inches at the base. The edges of the columns are reinforced with L-bars, 2 inches wide and 1/5 inch thick. The columns are connected by a base of armored concrete 60 inches wide and 12 inches deep. The number of columns under each beam varies with the width of the viaduct, but the maximum distance between consecutive columns nowhere exceeds 6 feet.

This construction is interrupted by a projected street, which is crossed by the method already described. The crossing is followed by 15 normal arches, terminating in a large pier. Beyond this point the viaduct is not designed to carry trains and it is constructed of floors, beams, and columns of armored concrete, arranged to accommodate the necessary stairways and auxiliary buildings.

Four distinct methods are employed in the construction of the section outside the city which was commenced in 1906. This section is 3,150 feet long and includes 6 street crossings and 3 aqueduct crossings, in addition to 79 normal spans. Only flat and round iron are used for reinforcing and, except at the street crossings, the armored concrete structure rests directly upon piles.

The normal spans resemble those of the city section, but the 4 columns of each pier rise from an armored concrete girder having a cross-section in the form of an inverted T, with a base 8 feet wide, 28 inches thick at the middle, and 20 inches thick at the edges. This girder rests on 22 piles, the heads being surrounded by spirals of round iron and imbedded in the concrete. The foundation girders at the two ends of the span



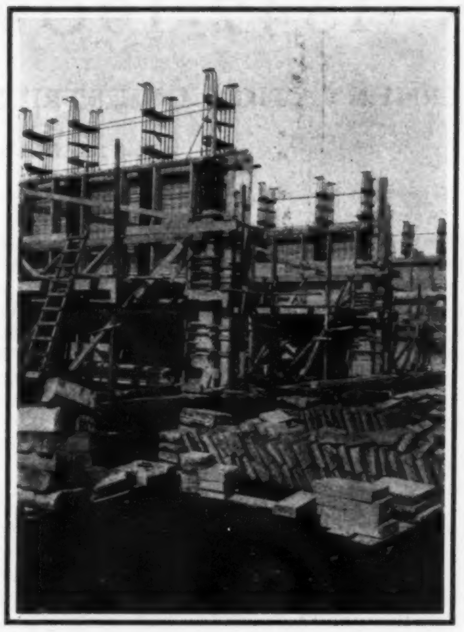
NORMAL SPANS IN COURSE OF CONSTRUCTION.

AN ARMORED CONCRETE VIADUCT.

are connected by 4 longitudinal girders 14 inches wide and 51 inches deep, and these are connected by an intermediate transverse girder of the same dimensions, forming a strong and rigid foundation.

The street crossings differ little from those of the city section.

The massive piers of street crossings serve not only to support the long bridge spans but also to resist longitudinal stresses caused by unequal contraction, starting and stopping of trains, etc. Hence in the section outside the city, where street crossings are far



CONSTRUCTION OF CAISSONS FOR CASTING THE PIERS.

apart, it has been deemed necessary to replace, in some of the normal spans, the longitudinal girders at the top and bottom of the columns by 12-inch walls, extending from the heads of the piles to the floor supporting the roadbed, and to connect these walls at the bottom by a bed of armored concrete, 20 inches deep, and extending 8 inches below the tops of the piles. The longitudinal walls are connected also by 6-inch front and rear walls.

One of the water conduits is crossed by the method adopted for street crossings. The other two conduits are small enough to be included within normal spans, but as it was necessary to omit the longitudinal girders connecting the bases of the columns, the discontinuity in the foundations thus caused was compensated by the construction of four thick longitudinal walls resting on soles similar to those used beneath the columns. These walls are connected by 6-inch front and rear walls and by a 4-inch floor, which covers the water conduit.

THE FORESTS OF THE PHILIPPINES.

ABOUT ninety per cent of the forests of the Philippines, which by the way have a growth computed to be 1,400,000,000 cubic feet, is going to waste while the world is clamoring for timber. These vast forests of fine woods contain more lumber than three times the yearly cut in the United States. The ebonies, mahoganies, ironwoods, narra, and all manner of rare and precious species, that need only the modern methods of handling timber to make Monte Cristos of the needed lumbermen, are beckoning with their aged arms to the thrifty American to come and harvest his fortune.

Only two important concessions have been granted to lumbering concerns by the Philippine government, one to the Mindoro Lumber and Logging Company, on the east coast of Mindoro, and the other to the Insular Lumber Company, in the northern part of the island of Negros. These two concerns each have a twenty years' lease, and are already doing an enormous business with handsome profits.

The concession granted to the Mindoro Company includes the forests on the low coastal plain near the Bongabong River, and is on typical agricultural land. This makes the property even more valuable after the timber has been cleared away. This tract contains something like seventy square miles, a great portion of which is to be cleared up within a few years. The Philippine Forestry Service in making surveys took seven commercial tree species as a basis for counting. These species represented more than one-half of the total stand of timber on the tract. The stand of valuable merchantable timber on the forested portion of the tract is large. One portion of the concession, containing 3,500 acres, has standing on it more than four million feet, board measure, of narra above sixteen inches in diameter. This represents but eight per cent of the stand of commercial timber on this small tract.

In contrast to the Mindoro concession, the Negros concession represents an entirely different type of forest. This tract lies back of the sugar lands, at the foot of Mount Silay, near Cadiz Nuevo. Ninety per cent of this concession, comprising an area of sixty-nine square miles, is in heavy timber of the third and fourth group species. In making the survey of this valuable tract of timber land, six merchantable species were counted. These represented ninety per cent of the stand of the timber on the tract. In estimating the stand of this timber, trees of sixteen inches and over in diameter only were counted, and the stand was computed to be 35,000 feet, board measure, to the acre. Some idea may be had of the denseness of these forests from the fact that there are few pine forests in the Southern States of this country that would furnish a third that many feet, board measure, to the acre.

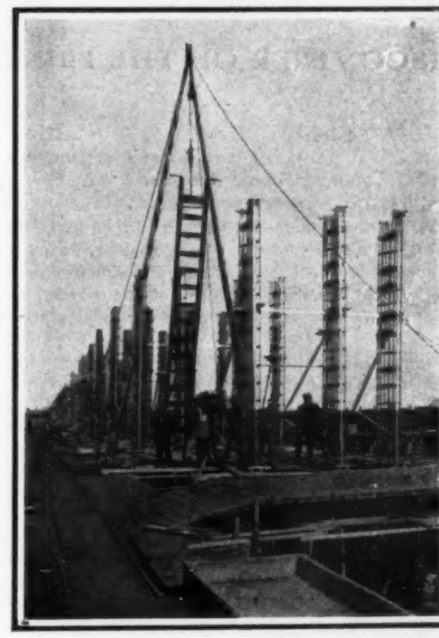
There are many millions of feet of timber in the Philippine forests that should be cut in order to properly thin out the dense growth. For instance, the Forest Service has found four trees growing on a space required for one. That one so freed would put on more wood each year than the four together. The question as to whether three hundred or three thousand trees should remain on an acre is where the real value of scientific forestry comes in. For the purpose of making a start at thinning out some portions of the forests, there is an act in force in the islands which allows a resident to cut or have cut for himself from the public forests, without licenses and free of charge, such timber, other than timber of the first group, and such fire wood, resin, forest products, stone and earth, as he may require for house building, fencing, boat building, or other personal use of himself or family. But timber thus cut is not allowed to be sold.

This would seem a good chance for the thrifty American lumbermen, who see the end of their industry in the not far-distant future. The transferring of their capital to our insular possession would most certainly mean the making of their fortunes in a few years.

According to recent reports a good price is paid in Hong Kong for every stick of timber from the Philippine Islands, besides the local demand being great. Besides, dealing in fine woods is not like handling the common pine. Pine at the best sells for one cent a foot; mahogany and the other fine woods bring one dollar and more a foot.

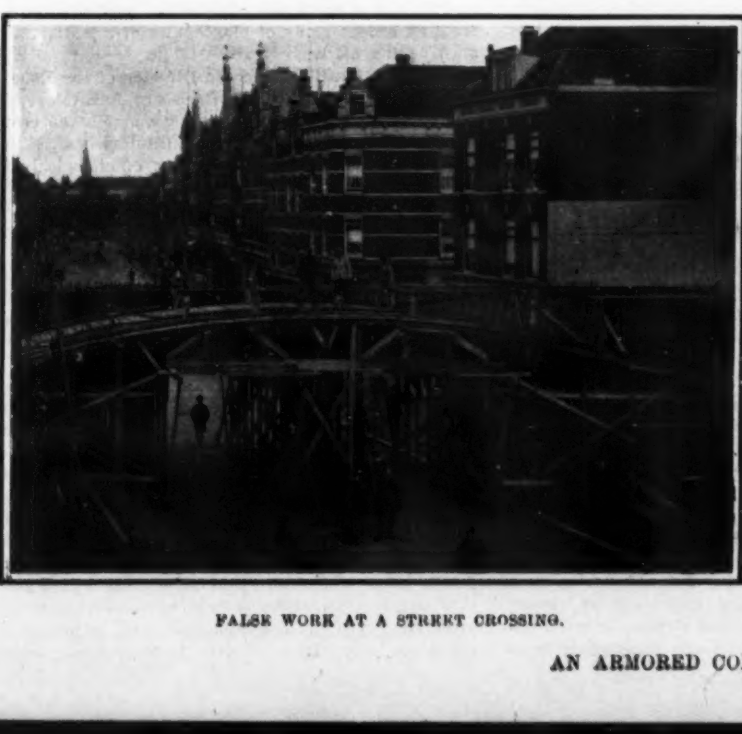
UTILIZATION OF THE METHANE FROM COAL SEAMS.

INFORMATION respecting a very interesting utilization of the dreaded explosive hydrocarbon of coal seams,

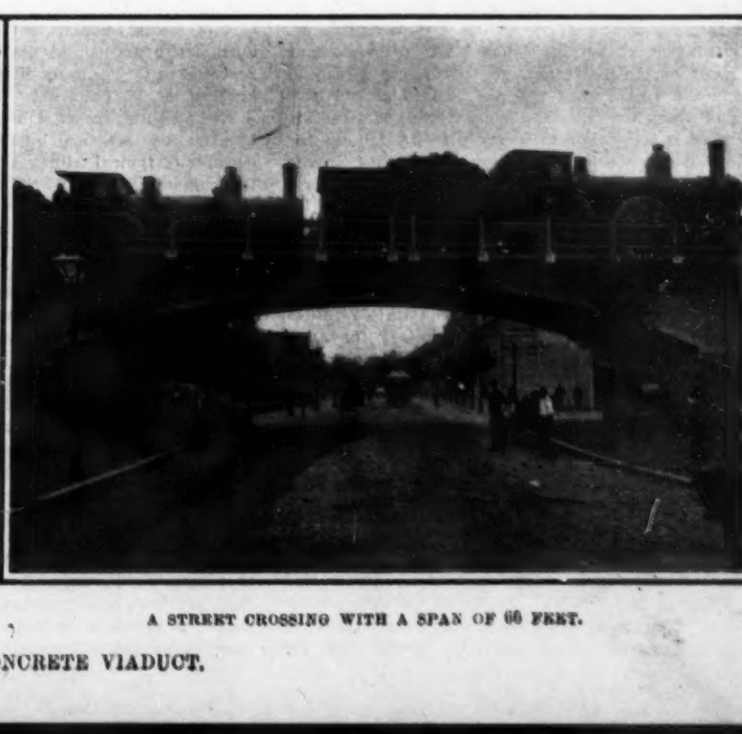


ERECTION OF IRON PARTS OF PIERS.

methane CH_4, has recently become available from the Frankenholz Colliery of the Frankenholz Bergwerks-Gesellschaft, near Mittelbesebach, in Rhenish Bavaria. The mine has a depth of 500 meters, and before attacking the coal seam at that level it was deemed advisable to bore to a depth of 50 meters in order to see whether much gas might have to be dealt with. When this was done a great deal of gas escaped under considerable pressure, and a pipe-line of 1,500 meters length (nearly 1 mile) was taken to the surface. This was in February, last year. As the pressure of the gas was still 12 atmospheres in June, 1908, the Dingler Maschinenfabrik A.-G., of Zweibrücken, was asked to fit up the Lancashire boilers of the colliery for burning this methane. In order not to waste any heating surface of the two internal furnaces, and to secure a complete combustion of the methane, the following arrangement has been adopted. Two combustion chambers, consisting of two cylinders placed alongside one another, have been constructed in front of the boiler, each chamber communicating, through a neck of smaller diameter than the combustion chamber, with the internal furnace. The gas is introduced through the front of the cylinder by a central pipe, inside which a small air-pipe has been provided. The main air supply is, however, through a crescent-shaped inlet, closed by an adjustable slide. The front of the chamber is



FALSE WORK AT A STREET CROSSING.



A STREET CROSSING WITH A SPAN OF 66 FEET.

AN ARMORED CONCRETE VIADUCT.

further fitted with a door; through this door a torch is introduced before the gas admission valve is opened, to fire the jet before an explosive mixture is formed. The combustion chambers are built of firebrick, and a layer of asbestos is interposed between the outside of the firebricks and the cylindrical iron shell. The gas is fairly pure methane, containing about 8 per cent of nitrogen, traces of oxygen, and some water vapor. As far as possible this vapor is condensed in the pipe-line of 6½ inches internal diameter, which is, for this purpose, provided with cylindrical condensers. Two methane bore-holes supply sufficient gas for two boilers, each of 700 square feet heating surface, and 40 kilogrammes of steam are produced per square centimeter of heating surface per hour (about 9 pounds per square foot). The temperature of the flue gases leaving the boiler furnace does not exceed 280 deg. C. (536 deg. F.). We have not yet received any exact determination of the gas consumption; but it is estimated that the methane burned is calorically equivalent to about 16 tons of average quality coal per 24 hours. We understand that it is intended to resort to further boring, with the object both of increasing the safety of the mine and of utilizing the methane gas. In several of our mines the escaping methane is used for illumination; but we are not aware of any case of burning the gas for the purpose of raising steam.—Engineering.

EMIL CHRISTIAN HANSEN—1842-1909.

DISCOVERER OF THE PRINCIPLE OF THE PURE CULTURE IN FERMENTATION INDUSTRIES.

BY J. CHRISTIAN BAY.

The death of Dr. Emil Christian Hansen, the discoverer of the principle of pure culture of micro-organisms involved in industrial technology, removes from the circle of modern botanists a characteristic and most valued member. The art of industrial biology loses its founder, and Denmark one of its greatest men.

Prof. Hansen's life exemplifies a most happy form of scientific specialization. The man is typical of the successful scientist of the present age, the scientist typical of the modern school of technical application. Therefore, the life now closed, and its results, deserve to be widely known.

The nineteenth century was, considered from a biological point of view, the era of the microscope. The discovery of the cell as an organism, and the observation of unicellular organisms, led to a wide extension of our knowledge of life phenomena, and, on the other hand, to a wonderful development of the field of cultivated organisms, large as well as minute.

Micro-organisms had been studied; beer, wine, vinegar and butter had been manufactured for centuries, when the Danish investigator's attention became fixed upon the problems involved therein. This was thirty years ago. The attention of Hansen, after he had reached the stage of independent biological investigation, centered itself at the points where Pasteur had left.

For many years previously the question of a good and constant product in the manufacture of wine, beer and butter, had been the order of the day. Pasteur had, in his famous work on fermentation, attained the very important result that a pure product in the brewery depends upon a pure yeast, a yeast free from bacteria. It had been found that "off" flavors in the fermentation industries were owing to bacteria that developed out of their proper place. This was true, but, as Hansen showed by his researches of the seventies and the beginning of the eighties, only part of the truth. After having assumed the directorship of the physiological department of the munificently endowed Carlsberg Laboratory, in Copenhagen, Hansen began a series of studies on the rôle and fate of yeast in the brewery and in nature, through which it was found that there are distinct species of yeast, as, indeed, there are distinct races of all cultivated plants and animals. The problem of a pure and constant product was synonymous not only with that of the elimination of bacteria; it meant the selection of favorable species of yeast and their perpetuation in the brewery.

Hansen solved these questions and developed the results into practical methods by the most ingenious experimentation known in biology. His principle was the study of the individual cell. He found a method by which a single yeast cell can be isolated out of a mass of yeast, and its development followed. In this way only is it possible to secure a seed-yeast consisting of but one species, or variety. Pure yeast, in the sense of Hansen, meant not only yeast free from bacteria, but one species of yeast free from admixture of "wild" forms.

It should be remembered also that Hansen, independently and before Koch, invented the solid nutritive substratum for the artificial culture of bacteria. This superseded the one-sided use of fluid culture media and was an important step in the direction yet followed in modern bacteriology, tending toward the study of the individual organism as the valid basis of the study of the form group.

After the period of laboratory experiments came that of the application of the results. The Carlsberg breweries, in Copenhagen, were the pioneers. There pure cultures were first used in a small way, but afterward the entire system was based upon isolated races of yeast in pure cultures. Hansen and Kühle invented an apparatus for the propagation of yeast on a large scale. There were no patents, no personal or clannish profits involved in the new system. Every detail of the discoveries and inventions was freely at the disposal of the brewing interests of the world. The Carlsberg methods, and Hansen's principles, rapidly found favor in other European countries, and in America and Australia. The selection and the authoritative examination of the yeasts, together with the isolation of industrially important forms, remained with the Danish investigators—Hansen, Jörgensen, Holm, Poulsen, Grönlund—only until the other countries had developed a system of laboratories for the study of fermentation. Since the middle of the eighties, every country in the world has sent to Denmark students that learned the methods of pure cultivation and their practical application.

Hansen's work was confined to the yeasts and to a single group of bacteria (the bacteria of vinegar manufacture), but it is many-sided. His laboratory methods have become the standard ones for work in mycology, and the many-sidedness has served as a model. Not content with the knowledge of the fate of fermentation organisms in the laboratory, did he follow their circulation in nature. He found the conditions of their resting-forms (spores), followed their life in the air, in the ground, in the water. He entered upon a laborious study of their variation and its causes. His experiments will undoubtedly remain, as they are now, models for all similar undertakings in the field of micro-organisms.

In the meantime, others carried the Carlsberg spirit into other fields. Prof. Storch, of the Royal Danish Agricultural Experiment Station, began in the eighties the study of lactic acid bacteria that led to the isolation of forms peculiar to the production of first-class butter with a constant flavor—a work that has been repeated in this country, independently and brilliantly, by Prof. H. W. Conn.

The manufacture of wines in Germany and France likewise was benefited by Hansen's discoveries. Pure cultures of typical wine yeasts have been developed at Geisenheim by Prof. Wortmann and his school, and in later years by a number of other stations. In bread yeast attempts have been made at the application of the pure culture method. The crowning glory of the scientific methods of Pasteur, Hansen and Koch, may be said to have been reached when, in 1892, Dr. Marshall Ward succeeded not only in separating the ginger-beer grains into their component organisms, but even in producing new grains by a biologic-synthetic method.

And this great investigator, in addition to all this, succeeded personally and professionally in a pure culture of those qualities that made his brother of nearest mental kin, Pasteur, unforgettable in the history of biology. Born amid the most modest of outward circumstances; being obliged to struggle for many years against illness and want, nay, poverty; slow in maturing for his ideals, he had gone through experiences that would have felled most men. The practical value of his discoveries must be reckoned in millions, nay, hundreds of millions, yet Prof. Hansen subsisted until the end of his days on a modest professor's salary. While the director of the brewery with which the Carlsberg Laboratory is connected enjoyed a princely income—the Carlsberg Breweries now form a trust fund for scientific study—Hansen himself lived and died a man of very moderate means. He was born in 1842 and died in Copenhagen, August 27th, 1909.

Personally, Hansen, in accordance with his principles, was open and unreserved. His free-handedness and hospitality is known to every foreign investigator that called upon him in person or approached him for advice. He had personally struggled so hard against untoward circumstances and calm antagonism, that he could afford no selfishness. But few botanists of the present day reaped as much honor in the end as fell to Prof. Hansen's share, and with still more few these honors were less visible on the surface. When a scientific pupil had once won his affection, he was followed by the master's kindness until the very ends of the world. But few days passed, even during periods of intense activity in his laboratory, when he did not visit some one ill and destitute, or find some forlorn child in want of material and moral help. While his fame spread across the world the little ones in the poverty-stricken districts of Copenhagen's uttermost West End knew that other side of his mind which was hardly less sympathetic than the one evident in his discoveries—he himself had been a struggling child!

His knowledge of the personal history of the exact and natural sciences was phenomenal, and was derived from an ardent study of biographies of scientists pursued during his early years.

From 1878 until the end the Director of the Department of Physiology of the Carlsberg Laboratory, he has made, in his faithful co-operation with the chemist Kjeldahl and with efficient, skillful assistants, this laboratory one of the great centers of biological and biological-industrial investigation.

THE TRUE FUNCTION OF BIRDS.

Birds and insects are dealt with in several aspects in the newly-issued Year Book of the United States Department of Agriculture. The Secretary for Agriculture (the Hon. James Wilson) tells us in his annual report that in work concerning injurious insects the United States has been a leader among nations. Systematic observations have been made to identify the injurious and useful birds and wild animals. In a general way they had shown that it was true that most of the birds were more useful to agriculture than otherwise, and the increasing understanding of this fact had undoubtedly checked the ruthless destruction of non-game birds, and was now promoting their preservation. Some of these birds were of large economic value to the farmer. The service of the native sparrows in destroying weed seeds had been valued at many millions of dollars annually. Were it not for the woodpeckers and other insect-eating birds there would be forest destruction. Caterpillars which destroy the foliage of fruit and shade trees are the food of birds, while the scale insects that infest fruit trees are found to be the food of no fewer than 37 species of birds.

The relationship between insects and birds is the subject of a special report by Prof. F. E. L. Beal, in charge of the department of economic ornithology of the Biological Survey. The point has been raised that, in the matter of insect destruction, birds are indiscriminate, and eat ants without regard to species or to their economic significance. It has been asserted that in devouring useful insects birds counteract all the good they do by eating harmful ones. This side of the question has been specially investigated, with the result that it is shown to be undoubtedly true that birds destroy many useful insects, these in many cases forming a very respectable percentage of the total food.

But while this at first sight may appear to be an argument against the usefulness of birds, it is shown that a broader philosophy will show that this is exactly what they are intended to do. Whoever expects to find in birds beneficent organisms working with a sole view to the benefit of the human race will be doomed to disappointment. Birds eat food to sustain life, and their selection is guided entirely by considerations of their own. The examinations of the crops of insectivorous birds which have been made in America, taken as a whole, show that they eat insects in about the proportions in which the species exist in nature. Many interesting facts are given in support of this view, no details being more interesting than those which show that so-called protective devices of some insects are, after all, but little protection. In spite of protective coloration, protective or mimetic forms, nauseous odors,

acrid secretions, and defensive armatures, insects so protected are found and eaten by birds, and in many cases form a considerable percentage of the average annual food.

The result of the inquiry indicates that the true function of insectivorous birds is not so much to destroy this or that insect pest as it is to lessen the numbers of the insect tribes as a whole—to reduce to a lower level the great flood-tide of insect life. That this is the true relation of birds and insects may be inferred from the fact that the two have lived together for countless ages, and the balance of nature has been preserved except as disturbed by the operations of man. Birds have not wholly destroyed the predaceous and parasitic insects on the one hand, nor, on the other, have they, so far as we know, exterminated any vegetable-eating pest; but they have successfully held the balance between the two, and kept both at such a level as has subserved the best interests of the animal and vegetable world. Altogether it is claimed birds do little harm by eating insects indiscriminately.

CRYSTAL ARCHITECTURE.

ITS SEVEN STYLES.

BY DR. A. E. H. TUTTON, F.R.S.

The proverbial importance of the number seven is once more illustrated in regard to the systems of symmetry exhibited by solid matter in its most perfectly organized form, the crystalline. For there are seven such systems or styles of architecture of crystals, just as there are seven distinct notes in the musical octave, and seven chemical elements in the octave or period of Newlands and Mendeléeff, the eighth or octaval note or element being but a repetition on a higher scale of the first.

A crystal appeals to us in two distinct ways, first compelling our admiration for its beautifully regular exterior shape, and next impressing us with the fact of its internal homogeneity, expressed in the cases of transparent crystals by its perfect limpidity, and the obvious similarity throughout its internal structure. As it is with human nature at its best, the external appearance is but the expression of the internal character.

The purpose of this discourse is not so much to dilate upon the seven geometrical systems of crystals, as to show how they are occasioned by differences in the internal structure, and to demonstrate this internal structure in an ocular manner unfolding at the same time some interesting phases of recent investigation.

In order to remind ourselves of the seven crystal systems, a series of seven lantern slides will be exhibited, prepared from photographs of real small crystals, taken by the lecturer with the aid of the microscope and camera while in the act of formation on a microscope slide. To the Greeks, whose wonderfully perfect knowledge of geometry we are ever admiring, the cube was the emblem of perfection, for like the Holy City, lying "foursquare," described in the inimitable language of the book of Revelation, "the length and the breadth and the height of it are equal." Moreover, even when we have added that all the angles are right angles, these are not the only perfections of the cube, for they carry with them, when the internal structure is developed to its highest possibility, no less than twenty-two elements (thirteen axes and nine planes) of symmetry.

At the other extreme is the seventh, the triclinic, system, in which the symmetry is at its minimum, neither planes nor axes of symmetry being developed, but merely parallelism of faces, sometimes described as symmetry about a center, and in which there are no right angles, and there is no equality among adjacent edges. Between these two extremes of maximum and minimum symmetry we have the five systems known as the hexagonal, tetragonal, trigonal, rhombic, and monoclinic, possessing respectively 14, 10, 8, 6, and 2 elements of symmetry. Photographs of real crystals belonging to all these seven respective systems will now be thrown on the screen. All crystals do not possess the full symmetry of their system, each system being sub-divisible into classes possessing a definite number of the possible elements. Altogether there are thirty-two such classes, and their definite recognition we owe to the genius of Von Lang and Story Maskelyne.

The characteristic property possessed in common by all crystals is that the exterior form consists of and is defined by truly plane faces, inclined, in accordance with one of the thirty-two classes of symmetry, at specific angles which are characteristic of the substance. This has only been proved to be an absolute fact within the last few years, although asserted by Haüy so long ago as the year 1783; for the numerous cases of so-called "isomorphous" salts, the first of which were discovered by Mitscherlich in the year 1820, were for long believed to be exceptions, and until the year 1890 no actual evidence one way or the other was forthcoming. But it was eventually shown that the crystals of the members of an isomorphous series did differ, both in their angles and in all their other crystallographic and physical properties, although in the cases of the angles the differences were very small. Moreover, the differences were shown to obey a simple but very interesting law, namely, that they were functions of the atomic weight of the chemical elements of the same family group whose interchange gives rise to the series. A series of lantern slides will next be shown to illustrate this law.

All crystals possess one other obvious property, that of homogeneity, and we now know that it is the character of the homogeneous substance which determines the external form. There are no less than 230 different kinds of homogenous structures, neither more nor less, the elucidation of which we owe to the independent recent labors of Schönflies, Von Fedorow, and Barlow. And it is a significant fact that the whole of them fall naturally into the thirty-two classes of crystals, leaving no class unaccounted for. Of these 230 modes of regular repetition in space fourteen are the space-lattices long revealed to us by Bravais, and all recent investigation concurs in indicating two facts, first, that it is the space-lattice which determines the crystal system, and, second, that it is the arrangement of the chemical molecules which is represented by the space-lattice. Each cell of the space-lattice corresponds to a molecule. The structure is certainly not solid throughout, however, part only being matter, and the rest ether-filled space, the relative proportions and the shape of the material portion being as yet unknown. We limit ourselves therefore to considering each molecule as a point, and we draw the lattice as a network of three systems of parallel lines, parallel to the directions of the three principal crystal edges, analogous, according to the system of symmetry, to those of the cube. The points of intersection we consider as those representing the molecules, inasmuch as any point within the limits of the cell may equally well be taken to represent the cell and the molecule, provided the choice is analogously made throughout the structure. Such a space-lattice, one of the most general, triclinic, form, is shown on the screen.

It has recently been found possible to determine the relative dimensions of these molecular cells, the distances of separation of the points of the space-lattice, in those cases where we know that the structure is similar, as in isomorphous salts; and the interesting discovery has been made that the "molecular distance ratios," as these space dimensions are called, are functions of the atomic weights of the interchangeable members of the family of chemical elements constituting the series, just as the crystal angles have been shown to be.

We are now able, moreover, to take yet one further step, for the chemical molecules are composed of atoms, and it has been indubitably shown that the atoms occupy definite positions in the crystal. For when we replace, say, the alkali metal in a sulphate or selenate, by another, we observe a marked alteration in the crystal angles and the molecular distance ratio along a particular direction, this direction being the same whichever metals of the group are interchanged; whereas if we replace the sulphur by selenium, a similar kind of alteration occurs, but along a totally different direction. Now we know that the atoms are arranged in the chemical molecule in what is known to chemists as their stereometric arrangement, depending on the maximum satisfaction of their chemical affinities. Hence this important experimental fact of the occupation by the atoms of definite positions in the crystal proves, firstly, the homogeneous similarity of arrangement of the molecules, and, secondly, explains why we have classes or subdivisions within the systems. For it is the arrangement of the atoms within the molecule which causes the variations of the degree of symmetry, within the limits described by the system and space-lattice; in other words, which determines the class.

Now, obviously, any one of the atoms in the molecule may be chosen to represent the latter, and the points thus chosen analogously throughout the structure will constitute the molecular space-lattice. Hence the whole structure may be considered as made up of as many interpenetrating similar space-lattices as there are atoms in the molecule. The crystal structure will thus be dependent on two factors, the space-lattice and the scheme of interpenetration of the space-lattices, the former dominating the style of architecture, the crystal system, and the latter the vagaries of the style, the crystal class. Sohncke has shown that there are sixty-five such vagaries possible, which he terms regular point systems, and these coincide with sixty-five of the 230 possible modes of partitioning space.

These are the broad simple facts, now proved up to the hilt, which explain the majority of crystal structures, all, in fact, but a very few, of the more complicated classes of the thirty-two. For the remaining 165 ways of appropriating space all fall into a very small number of crystal classes. They are of very great interest, however, and involve an entirely new principle, that of "reflective" or "mirror image" symmetry, enantiomorphism as it is technically termed, and include those crystals which possess the remarkable property of rotating the plane of polarized light. These are the cases whose geometrical possibility has been accounted for by the simultaneously independent work of Schönflies, Von Fedorow, and Barlow, and to which we were experimentally introduced by the discovery of the right- and left-handed varieties of tartaric acid by Pasteur. The latter has since been followed by the revelation of many similar cases of two forms of the same chemical substance, related crystallographically and structurally like a right-hand to a left-hand glove, and optically differing by the direction in which they rotate a beam of plane polarized light.

With this discovery and explanation the elucidation of the seven styles of crystal architecture and their thirty-two subdivisions become *un fait accompli*, and although many difficult problems still confront the crystallographer, problems of vast importance to chemistry, the groundwork is now securely laid, the memorable achievement of the last twenty years. The results, moreover, are in entire accordance with the now well-proved fact that the chemical atom is composed of electronic-corpuscles. For the definite orientation of the atom and its sphere of influence within the molecule and the crystal is thereby accounted for, the motion in the solid state so frequently hitherto attributed to the atom being a myth, such motion relating, in fact, to the corpuscles within the atom.

The rest of this discourse will now be devoted to experimentally demonstrating, with the aid of a projection Nicol-prism polariscope of original construction, firstly, the optical behavior of the simpler kinds of crystal structure, and, secondly, that of the interesting cases of mirror-image symmetry. Quartz in particular will afford us not only some magnificent phenomena by reason of its right- or left-handed structure, but also a most instructive example, in its repeatedly twinned and all-but-molecularly alternating variety of amethyst, of the phenomenon of "pseudo-racemism." For it is the display of this phenomenon which often renders a crystalline inactive substance so difficult to distinguish from a truly "racemic" substance, which, as in the case of racemic acid itself, the optically inactive variety of tartaric acid, is a truly molecular compound of the right- and left-handed active varieties, the optical activity being neutralized and destroyed by the act of combination.

* The first evening discourse delivered before the British Association at Winnipeg.

It is well known that a direct-current shunt dynamo will only self-excite and develop pressure for one direction of rotation corresponding to the remanent magnetism. One of the German electrical engineering firms makes use of this fact to provide a means for obtaining a unidirectional current irrespective of the direction of rotation. Two shunt machines are coupled in any suitable manner and connected in series. The shunt coils are wound in opposite directions, so that for either sense of the rotation only one machine develops pressure. It is advisable to supplement the remanent magnetism by an auxiliary winding separately excited. The two machines may also be combined in a single machine.

MARINE PLANKTON.

THE BIOLOGICAL HISTORY AND IMPORTANCE OF MICROSCOPIC MARINE LIFE.

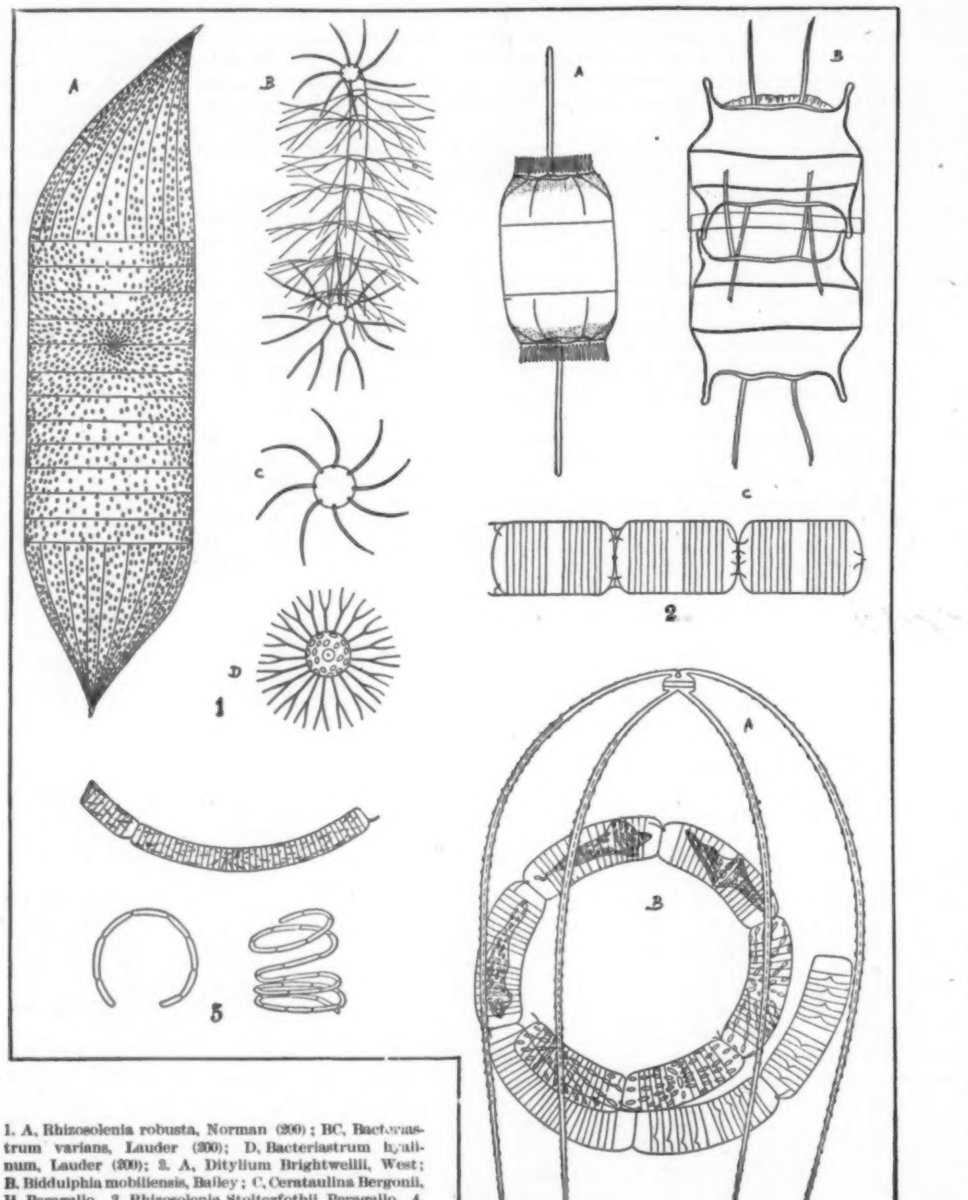
BY EMILE GADECEAU.

THE animated world known by the term "plankton" was closed to us before the invention of the microscope, which reveals in it marvels of variety and beauty of form and of symbiotic adaptation. Furthermore, the researches of the last few years have demonstrated the great practical importance of the plankton to the ocean fisheries.

The intensity of life in the water is manifested, on the one hand, by organisms which live at the bottom of seas, lakes and rivers, either free or attached to the ground, stones and rocks. These organisms are called, collectively, the "benthos," from a Greek word meaning depth. But this exuberance of vitality is shown still more conspicuously in the vast multitude of creatures adapted to a floating life, which remain in suspension near the surface of the water subject to the caprices of waves and currents, either without any power of independent motion, or too little to prevent their being carried away by the water. These organisms constitute the plankton. This name, derived from a Greek word meaning to wander, was introduced, together with benthos, by Haeckel, in 1890.

The plankton includes organisms which are obviously animal (crustaceans, copepods, protozoa, etc.), unicellular types which appear intermediate between the two kingdoms (peridinians), and, finally, microscopic vegetable organisms or protophytes (diatoms). Diatoms, peridinians and copepods are the chief elements of the plankton.

The vegetable plankton, or phytoplankton, alone will occupy us in this article. This is the productive element, while the animal plankton, or zooplankton, is a consumer, which depends upon the former with the rigor which is manifested throughout all nature in regard to the dependence of animals upon plants. Vegetable organisms, even the simplest, the unicellular protophytes, are essentially characterized by the power of synthesis with the aid of chlorophyl under the influence of sunlight. They assimilate inorganic substances, which animals cannot do. Hence the phytoplankton, in view of its enormous quantity, becomes an extremely important factor in the alimentation of marine animals, for it constitutes the principal agent in the conversion of inorganic into organic matter. The study of the plankton was not taken up seriously until the middle of the last century. The German naturalist J. Mueller was one of the most industrious of the early investigators. In 1873, 1874, and 1875 the British ship "Challenger" made an extensive voyage of exploration, in which many interesting observations were made. The true importance of these investigations has recently been brought to light by Pouchet in France, and especially by Hensen in Kiel, the seat of the commission for the scientific study of the German seas. The researches of this commission, limited at first to the Bay of Kiel, were gradually extended to the Baltic and the North Sea at various seasons of the year. In 1889, Hensen, on the ship "National," conducted a great plankton expedition, which marks a date in the biographical exploration of the sea. The course of the expedition extended from Kiel to the southern point of Greenland, thence to the Bermudas, Cape Verde and Ascension Islands, and thence to the mouth of the Amazon, returning to Kiel by way of the Azores and the English Channel, thus tracing a great figure 8 across the Atlantic, and making more than four hundred great catches of plankton, the analysis of which has been published only recently.



1. A, Rhizosolenia robusta, Norman (200); BC, Bacteriastrum varians, Lauder (200); D, Bacteriastrum hyalinum, Lauder (200); 2. A, Ditylium Brightwellii, West; B, Biddulphia mobiliensis, Bailey; C, Cerataulina Bergonii, H. Peragallo. 3. Rhizosolenia Stolterfothii, Peragallo. 4. A, Chaetoceras peruvianum, Brightwell; B, Rhizosolenia Stolterfothii, Peragallo.

FIG. 1.—DIATOMS FOUND IN MARINE PLANKTON.

Ten years later (1898-1899) Chun, on the "Valdivia," explored the Atlantic and Antarctic Oceans. Numerous explorations and cruises have since been made, and the study of plankton has awakened general interest. The voyages of the "Scotia," the "Belgica," the "Siboga," the "Michael Sars" (1900), and the German Antarctic expedition of the "Gauss" (1902) have greatly increased our knowledge of the subject.

These researches have been complemented by the important scientific labors of the Swedes, Cleve, Ekman, Petersen, Aurivillius; the Danes, Ostenfeld and Schmidt; and the Norwegians, Hjort and Gran. They have led also to the establishment of the annual international conferences for the exploration of the sea, the first of which was held in Stockholm in 1899.

In view of the diversity of the questions which remain to be solved, the complexity of the biological problems and the practical applications, it is evident that the efforts of individuals or even of a single state will not suffice. The international agreement now in force includes: Norway, Sweden, Denmark, Russia, Great Britain, Germany, Holland, Belgium, the United States, and Canada. It is with painful surprise, that we observe the absence of France from this list, although the reports are published in French, and although the traditional initiatory mission of France, as well as her material interest in the problem, should have given her an important place in the association. These conferences form a new and very remarkable manifestation of international life, in a field which it had not hitherto entered.

In reviewing the results obtained by the expeditions mentioned above, we shall first glance at the curious adaptations of organisms to pelagic life. These adaptations are shown principally by various methods of retarding indefinitely the fall of the organism through the water. This result is accomplished by two principal methods. The first method is the diminution of the specific gravity by the addition of substances of small density, such as drops of oil, or by the introduction of a large quantity of water either into the body of the organism or into its gelatinous envelopes. By these devices the specific gravity of the body is made sensibly equal to that of the water. This method is shown chiefly, among the protophytes, by the *Cyanophyceæ*, the cells of which contain bubbles of gas which, under the microscope, resemble red dots, and by the diatoms, which produce large quantities of oil. The second method is the increase of friction, which retards the movement downward, a direction in which the surrounding water very rarely moves. The principal arrangements by which this object is accomplished are: the extension of the surface by additions of very light material, linear elongation, the formation of long hairs or ridges, and arrangement in linear colonies, straight, circular, or corkscrew shaped.

These adaptations are marvelously perfected in some of the diatoms (Fig. 1) and peridinians (Fig. 2). The increase of surface without appreciable increase of weight is especially remarkable in the comparatively gigantic diatom, *Anthelminella gigas* (Fig. 3), which, with a very small body of protoplasm, occupies a volume several millimeters in diameter, owing to its investment by a proportionally enormous and exceedingly fine membrane. Fig. 2 shows a number of peridinians provided with ridges and other appendages so arranged as to retard vertical descent.

The animal plankton, which is here mentioned only for the sake of comparison, exhibits the same modes of adaptation. Representatives of genera which normally have skeletons, shells or other heavy mineral parts exhibit in the plankton atrophied shells or none. The tissues are laden with a large quantity of water and form a jelly so transparent that the animal is almost invisible (medusas, *siphonophora*, tunicates, etc.) The organs of sense, the eyes and the otocysts, especially, become hypertrophied, and small air vessels, drops of oil and moving oar-like appendages are developed.

These adaptations are still more striking among the numerous organisms which belong only temporarily to

the plankton. Many of the deep water forms pass through a larval phase, during which they float near the surface and lead a purely planktonic life. These larvæ are so different in appearance from the adult animal that they were at first regarded as distinct species. From observations made in the course of the expeditions, it appears that the animal plankton is found in all depths down to and even beyond 16,000 feet, while the vegetable, or productive plankton, is confined to the upper and illuminated layers, because light is necessary for synthesis by means of chlorophyl. It is contained almost entirely within the upper 300 feet, it begins to diminish at a depth of 250 feet and disappears almost completely at a depth of 1,300 feet with the possible exception of certain denitrifying bacteria, which have as yet been little studied, but which appear to fulfill an important function in the metabolism of the sea.

Phæocystis Pouchetti and *Trichodesmium Erytræum* (Fig. 3) are "water flowers," which are found always very near the surface, the former particularly in the northern Atlantic, the latter in the Indian Ocean, where it is extremely abundant. It is this organism that gives the Red Sea its characteristic color. Certain other protophytes also give the sea special colors and, like certain marine animals, emit a phosphorescent light at night. Among these are the peridinians, *Pyrocystis noctiluca* and *P. fusiformis* (Fig. 4). These phenomena are caused by minute colored particles or chromatophores. The colors are red, orange, or yellow, but their chemical nature is not yet known.

In regard to geographical distribution, Haeckel has divided the plankton into pelagic or oceanic, and neritic, littoral or coastal. The latter is much richer than the former. The plankton of the coasts contains larvæ of a great many organisms of which the adult forms live at the bottom, while in the deep sea nothing rises from the bottom, but, on the contrary, the dead bodies of the plankton fall, and furnish food to the denizens of the depths.

In the ocean, where the plankton is distributed pretty uniformly, "shoals" are frequently observed. These are temporary accumulations of individuals of a single species, a diatom or copepod, or perhaps a larger organism, such as the medusa. Some of these shoals cover vast areas, so that a vessel occupies whole days in crossing them. When these shoals are composed of very minute organisms, they give the sea their special tint. The geographical distribution of the various groups has been carefully studied in the course of these great expeditions. We can give here only a few general facts.

Peridinians are distributed chiefly throughout the temperate and tropical seas. In the North Atlantic the number of species is limited, although the number of individuals is often so great that they completely dominate the plankton. In approaching the equator the number of species gradually increases, while the number of individuals appears to diminish.

The diatoms, the fundamental element of the plankton, are found in enormous masses in the temperate zone, and up to the highest latitudes, but with the complete exception of the polar sea, according to Hensen. They occur in much smaller numbers in tropical waters.

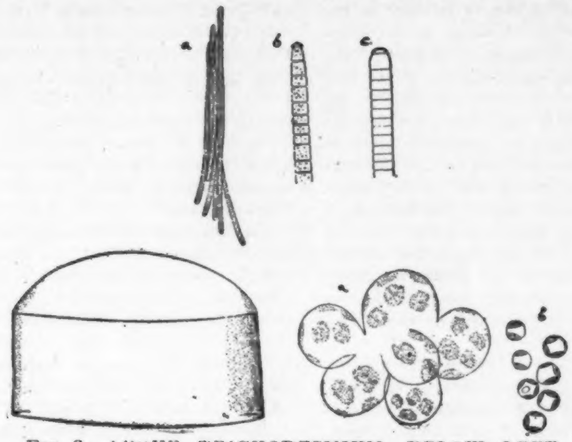


FIG. 3.—ABOVE, TRICHODESMIUM. BELOW, LEFT, ANTHELMINELLA GIGAS; BELOW, RIGHT, PHAEOCYSTIS.

The distribution of the plankton in the Antarctic Ocean, compared with its distribution in the Arctic, has given rise to interesting observations concerning the mooted question of bipolarity. These may be condensed as follows:

According to the collections made by the "Valdivia," "Belgica," and "Scotia," the peridinians appear to be totally absent from the Antarctic, where the diatoms constitute almost the whole of the vegetable plankton. The reports of all three expeditions note the astonishing abundance of diatoms in the Antarctic sea. In addition to the cosmopolitan species, the collections of the "Valdivia" have furnished five species common to Arctic and Antarctic oceans. One of these species, *Chætoceras criophilum* (Fig. 5), has never been found in intermediate waters.

The practical importance of these observations was made known by the fine researches of Cleve, who, in 1901, published a sketch of a general theory, which may be called the hydrographic theory of the migrations of plankton. According to this theory, each system of ocean currents carries its particular fauna and flora, which flourish in those currents because therein they find the biological conditions of temperature, salinity, etc., which are essential to their existence. Cleve established a certain number of types of oceanic and coastal plankton by which the various masses of ocean water may be characterized, and the currents which connect them may be traced. The alternating preponderance of summer and winter climates is mani-

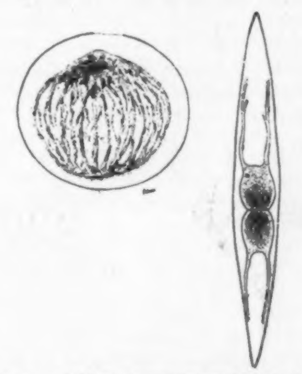
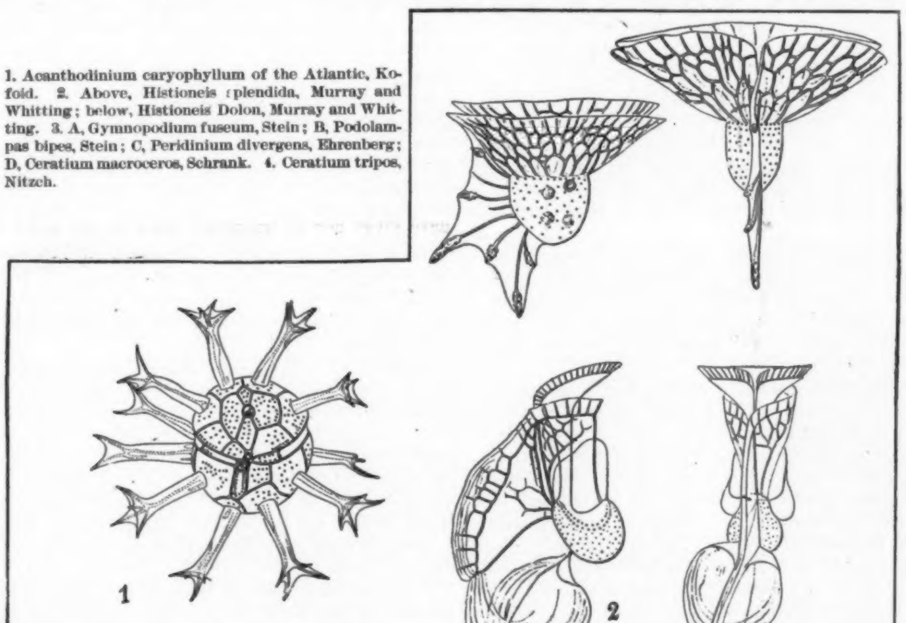


FIG. 4.—LUMINOUS PERIDINIANS (PYROCYSTIS).



1. Acanthodinium caryophyllum of the Atlantic, Kofoid. 2. Above, Histioneis splendida, Murray and Whitting; below, Histioneis Dolon, Murray and Whitting. 3. A, Gymnopodium fuseum, Stein; B, Podolampas bipes, Stein; C, Peridinium divergens, Ehrenberg; D, Ceratium macroceros, Schrank. 4. Ceratium tripos, Nitzch.

FIG. 2.—PERIDINIANS FOUND IN MARINE PLANKTON.

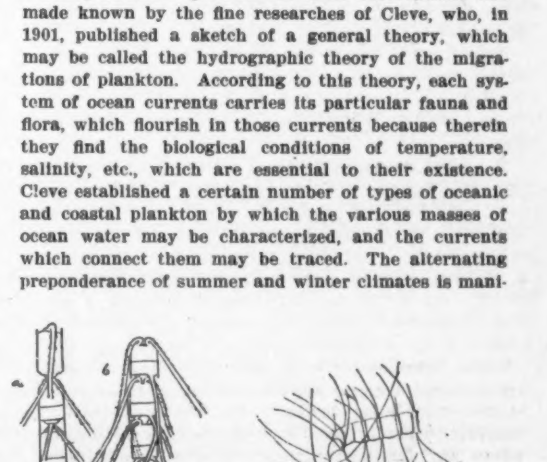


FIG. 5.—CHAETOCERAS.

fested by alternate extensions and retractions of tropical and Arctic waters and by corresponding variations to the plankton. The cruise of the "Michael Sars" in 1900 furnished data of prime importance regarding the relations of the general study of the plankton to ocean fisheries and pisciculture. For example, the cod (*Gadus morrhua*) is the most important product of the Norwegian fisheries. This fish appears on the coast in autumn and winter, but is absent in summer. The course of the annual migrations of the cod is not well known, but Hjort has observed that they come to the fjords of the coast to lay their eggs, which are pelagic, and float. But very few eggs or larvæ are found in the fjords. The necessary conclusion is that the eggs are carried out to sea by currents, and, in fact, Hjort has collected large numbers of eggs, larvæ and young codfish at a great distance from the coast. The examination of the stomachs of the young fish showed that they fed almost exclusively on plankton. Many full-grown codfish were also obtained; hence these, contrary to the current belief, maintain in summer a truly pelagic life, far from the coast and in seas of considerable depth. Their winter journey toward the coast was known, but their summer migration out to sea had not been observed. The importance of this fact to the fisheries is obvious. It is known, furthermore, that the Norwegian sea is invaded in winter by Arctic currents conveying very little plankton, while in summer the fish-bearing strata contain an abundant plankton, including, in particular, immense numbers of the copepod, *Calanus finmarchicus*. The migrations of the cod are probably determined by these variations in the food supply, and the Norwegian Sea affords them in summer an inexhaustible feeding ground. The migrations of the herring in the Atlantic are similarly dependent upon the same little crustacean. Another small crustacean, the *Euphausia*, forms immense shoals under icebergs in the Antarctic and forms almost the entire food of seals, penguins, and possibly whales. In the "Valdivia" expedition, Chun noted the abundance of the plankton of Fish Bay, at the Cape of Good Hope, which has always been famous for its abundance of fish.

In general terms, the zone of contact of polar and Atlantic waters is characterized by an enormous development of pelagic life, the abundance of which gives the water a greenish tint. Here are found the largest fisheries in the world, those of Iceland and Newfoundland.

But although the intervention of currents gives a general explanation of the comparative richness of different parts of the ocean, it does not solve certain problems of great practical importance; for example, the problem of the fluctuation in quantity, which is observed everywhere and is, without doubt, regulated by uniform laws. In all the cold and temperate seas, as in lakes, there are two annual maxima, in spring and autumn.

The intervention of physical factors, light, temperature, etc., in causing these periodical fluctuations, cannot be doubted, but it does not explain them completely. Another element is necessary—food supply.

Two sorts of food play essential parts with organisms which contain chlorophyl, nitrogenous food and carbonaceous food. Here the nitro-bacteria appear to play a preponderating rôle. The quantitative development of the diatoms depends upon a balance, maintained by temperature conditions, between them and the nitro-bacteria.

In early spring, as soon as the light becomes bright enough, the diatoms develop rapidly, owing to the abundance of nitrogenous food, which has not been drawn upon during the winter sleep. Later, as the temperature rises, the denitrifying bacteria become active, attack and destroy the nitrates, and liberate nitrogen, which escapes into the atmosphere. Furthermore, the heat of summer retards the development of the diatoms, while it favors that of the bacteria and peridinians. We must also take account of vertical upward currents caused by conditions of temperature and density, the general effect of which is to bring back continually to the surface the food substances which have been carried downward by gravity. Here, according to Nathanson, the carbonic acid dissolves in the water, forms an indispensable element in nutrition, and plays a preponderating rôle which has been almost completely ignored.

Despite the results which have been obtained, much remains to be done before definite conclusions can be drawn from the study of plankton, which is still in its infancy. One fact, however, has been clearly established, which was long suspected by the Norwegian fishers, namely, that the present and future state of the great fisheries, that is to say, the rational and economical exploitation of the sea, is essentially a question of biological oceanography, and of the thorough study of the plankton and its development.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

THE RED GOD OF THE SKY.

MARS AND HIS PROBLEMS NOW SPEEDING FAST AWAY.

IT is a battle of the astronomers, this question of Mars. Also it is complicated by the further fact that the slightest hint from the eyepiece of the telescope has set thoughtful men at work upon the enticing problem of life in other worlds than ours. Given the suggestion fancy may be counted on to fly.

Mr. Wells and his school have accepted the man of Mars, and a fine mess they have made of him. Mr. Tesla either has caught an etheric signal from the red planet or else he's going to catch one sometime, or else he knows how to go about it when he finds the time. The plains of Texas are to be vitrified with a mirror costing all of $10,000,000 in order to establish a signal service communication as soon as that branch of our military intelligence gets through with airshipping. An astronomer is or was to go up in a balloon into the ultimate zero of the cold of space equipped with tanks of air and machinery to pump it into his system, and there he was to bombard our neighbor with Hertzian waves.

Finest triumph of all this genius, the picture has been drawn of the man on Mars. He has been assumed to be æons of ages in advance of our culture and in that time he has advanced to accord with conditions we know not of. Certainly he is not a handsome object, but perhaps in the Martian pure intelligence mere comeliness is negligible.

But all these flights of fancy can have no foundation in demonstrable fact other than such as is visible through the instruments of astronomical observation. Thus it resolves itself down to a battle of the astronomers.

The great superior planets lie too far away from the sun, their day and their year so widely vary from our own conditions, the spectroscope tells such tales of their heat conditions, that it is impossible to form any conception of life upon their surfaces. It is only Mars, our next outer neighbor in the solar system, and Venus, next within our orbit toward the sun, which offer conditions of night and day and the changes of seasons at all comparable with those familiar to us.

Venus comes nearer to us than any of the heavenly bodies except our own satellite, so near at times as to be visible in broad daylight. But the conditions of illumination are so baffling as to preclude the obtaining of any familiarity with the surface conditions which may exist upon so much of the Venus disk as ever comes into view. Mars, however, though never at its nearest so near as Venus, offers conditions of better visibility.

It is not only when shepherds watched their flocks by night that the great red star has challenged the attention of men. Even in the culture of the Middle Ages, by no means so wholly unenlightened as it is habit to think, the influence of Mars was potent upon the affairs of men; brave leaders suffered no lack of courage for knowing Mars prevailed in the house of their ascendant with the wealth of astrology to preach the moral.

In the nights of these years of grace when one would wish to assume that centuries of education might have produced an instinct of sense Mars still smites the eye and the curious seek to be advised if Mr. Edison really has invented a star. Thus from the god of war to an electrician; verily the world remains utilitarian albeit the utilities vary in their relative importance.

In September of this year Mars was in opposition at its orbital point of greatest proximity to the earth, a distance of 36,000,000 miles. Year by year its distance at opposition increases until it is 60,000,000 miles away. Not for fifteen years will it come so close as this year.

Let us see what difference this makes in the thing seen. The telescopes of high power present the image of Mars as a disk in the same fashion that we see the disk of the moon at full. At the nearest opposition the disk of Mars subtends an angle of twenty-five seconds of arc, when the planet is at its farthest its disk is but four seconds. At its best it is more than six times as great as when it is at its farthest.

Feet and inches have become familiar terms of measurement, not so the terms of angular measure. One needs, therefore, some comparison which may set a general meaning in this statement of the size of the Martian disk.

A disk subtending an angle of twenty-five seconds of arc is smaller than a dime, only a little larger than the head of one's lead pencil. This is Mars when at its greatest in the eyepiece of the few really great telescopes. In a surface which a dime would hide lies the whole possibility of any knowledge of Mars which we may acquire.

For a moment compare with this the eight-inch disk on which the hemispheres of our familiar world are presented in the atlases and pause to figure out how much of the terrestrial physiography and the life of mankind could be figured out from an area as large as a soup plate. Then will come some sense of the fact that it must call for a lifetime spent in the study of the twenty-five-second disks coming so rarely.

Photography has been brought into service, but it can render no more than a partial aid. Only a few of the markings of the disk of Mars are strong enough to imprint themselves upon the most sensitive plates that chemistry has been able to produce. It is only under the most exceptional conditions of visibility and actinic sensitiveness that photography has caught even a spidery record of a very few of the thin markings which are called canals.

For the finer detail it is impossible to eliminate the human factor, the personal equation of the observer. It is his eye that must see the markings of the planet and it is his pencil that must make the record for later study. So long as the human factor plays so large a part, just so long will there be reason to doubt the accuracy of the record.

The beginning of the Mars problem lay in the invention of the telescope. The planet was by far the most conspicuous of the heavenly bodies, at least its better visibility outweighed the greater brightness of Venus. It was the target for the first of telescopes—each improvement in the optical mechanics of the telescope maker has brought with it a new train of observations upon Mars. Venus, because it rarely gets far enough away from the sun glare when its disk presents itself in any phase that might yield results, has practically dropped back into the position of serving at its transits for the mere measurement of parallax, and therefore the establishment of the earth's distance from the sun.

As far back as 1643 Fontana at Naples discovered spots on the disk of the planet, this being the parent observation from which has grown the whole family of the canals. With his poor instrument Fontana could scarcely believe the existence of the Martian spots, yet in his announcement of the thing that he had discovered he noted his feeling that if spots were really visible and if, as they seemed, they changed in position from night to night it might be the planet was in rotation.

It was not until 1666 at Bologna that Cassini found himself in possession of a better instrument which did establish the existence of the Martian spots which Fontana had seen. From his study of these spots, better to be described as general markings, Cassini in a month's time was able to announce the axial rotation of the planet within three minutes of the time now satisfactorily established, namely, 24 hours 37 minutes 23 seconds. The length of the year on Mars, the completion of its orbital movement about the sun, is 687 days.

After Cassini the Martian markings became better known. Their permanence, in all except one important particular, gave data upon which to pursue some study of their nature. From the fact that the same general markings were found in the same part of the disk at the same hours of the Martian day, that the observations of the present reproduced with great fidelity drawings made at much earlier periods, it was not difficult to establish as fact that we were seeing the surface of the planet itself and not merely a dense surrounding atmosphere such as seems to veil from our sight the real bodies of other planets.

If the observed markings were due to the presence of clouds in the Martian atmosphere it would be inconceivable on any theory of air circulation which we can imagine that for year after year the clouds should rest over the same spot and should preserve the same form despite the temperature changes which must attend the wide range of distance from the sun. For these and similar reasons the first idea was soon relinquished that we were looking from above upon a cloud mantle over the planet.

By consequence the idea arose that in the atmosphere of Mars, then assuming the existence of an atmosphere, fine weather reigned through all the sea-

sons, for it is readily inferential that the eastward progress of atmospheric cyclones over the earth, with their almost continental blankets of cloud, must obscure to the Martian observer from time to time the greater configurations of our planetary mass. The absence of such phenomena in the centuries of observation of the Martian disk argues the absence of water vapor in its atmosphere in anything like the proportion known in earth atmosphere.

The next great step in the discovery of Mars was made at Milan in 1877 by Schiaparelli. He announced that in the markings of the Martian disk he had identified a number of straight lines traced from radiant points or areas. To these fine threads or scratches he gave the designation of canals. His first announcement was followed in succession by others; that the lines were subject to a regularity of appearance and disappearance; that at certain times a well-defined line became twinned by a second line in close parallelism; that the appearance and vanishing of the lines, and in particular the twinning process, was governed by the waxing and waning of the Martian seasons.

It has already been remarked that there is one important exception to the observed permanence of the markings of the disk of Mars. This concerns itself with two bright spots which occupy varying areas at the two poles of the planet, and between them there is a fixed regularity in diversity, that as the northern spot of brightness enlarges its area its south polar companion contracts.

The southern bright spot had been known for some sixty years when Maraldi observed that it was subject to the most considerable variation in extent. It was not, however, until much later that the possession of a much greater equatorial telescope put it in the power of Sir William Herschel to observe similar phenomena at the northern extremity of the axis. When he was able to compare the synchronism with opposite signs of the two polar bright spots this distinguished astronomer was in the position to propound the theory that these localized brilliancies were due to seasonal changes in two ice caps such as are known to exist at the poles of the earth, despite its greater proximity to the sun.

Schiaparelli made use of Herschel's discovery for the explanation of his own discovery of the Martian canals. In its simplest form his argument, now greatly expanded by Percival Lowell who has succeeded him in canal observations and has indeed greatly overpassed him, is that we do not see canals as water carrying bodies in themselves, but that we are justified in inferring their existence from what we really do see, a vital point upon which observational astronomers are by no means in hearty accord, namely, areas of vegetation.

Taking as proved that there exist ice masses at the poles, it is assumed that the canals are great conduits extending to the melting face of the ice caps, drawing water toward the rainless equatorial regions, that laterals carry this water to such distance on either side of the main ditches as is found economical, that with the coming of the ice cap thaw the water reaches arable soil, and in no long time the result becomes visible to us when we look upon these narrow belts of fertility. Prof. Simon Newcomb, in opposing the theory of the visibility of mere canals, has pointed out that the minimum width which would become visible to us as a spiderweb line on the Martian surface cannot be less than sixty miles.

As soon as these theories had been formulated and had been popularized outside of the Astronomische Nachrichten, the ultimate record of all that is new in astronomical discovery, it became at once apparent that this involved the argument of design. The argument of design predicates the existence of a directing intelligence. At once the question of life on Mars offered itself to the study of astronomy and theology. It has raged for a generation and is no nearer solution than it was at the beginning.

Theological orthodoxy has settled the question in the negative. Very properly is this settlement made, for nowhere in revelation is there any provision for savable or damnable life upon any tributary planet of a geocentric universe. It is not the first debatable point of the cosmic physics which theology has determined. Such determinations have hitherto proved negligible. Therefore in this case the determination has nothing to do with the main facts at issue.

The astronomical argument, involving conscious intelligences only as incidents, is more systematically fought out, and the solution is not yet in sight.

Schiaparelli and Lowell after him have argued that the regularity of the fine lines in the distribution of their irregular arrangement is inconceivable except upon the hypothesis of governing design for the attainment of some rational end. The opposition presents a large mass of statistics of the cracks upon the moon and makes a stout showing that surface rupture of a planetary body may produce such ramification as appears in the markings of Mars either in the final stages of the loss of its inner heat or after the death of the planet by reason of the ultimate chill of zero space temperatures, the two periods being concurrent in the working for ages in proportion to the planetary mass.

The proponents of the lunar hypothesis make out the case for the absence of the element of design. The adherents of the theory of Martian canalicuiation for purposes of crop irrigation, which involves intensively the acceptance of the theory of beings possessed of the higher intelligence which alone can combat the deficiencies of natural conditions, argue in reply that the lunar cracks lack all resemblance to the Martian markings, and that whatever may have happened to a dying and now dead world has no bearing upon a planet still living, even though it may have advanced to greater age than we shall have to contend with in terrestrial conditions for several million years or ages to come.

The argument that Mars is still a living planet is for the present to rest on its possession of such a sufficiency of aqueous vapor as to admit of the support of living organisms of such cell structure as we may comprehend as living, although the arrangement and above all the specialization of the component life cells may not necessarily bear much resemblance to the observed balance of functions in our own bodies.

The proponents of the canal theory of Mars acknowledged that the planet of their enthusiastic study is imperfectly watered, that except at the rim of the two melting snowcaps it offers conditions of aridity under which we mortals of earth could not maintain life at all. But they claim that under Martian conditions the force of evolution has produced a race of such higher intelligence as to compass a network of irrigation machinery such that, drawing alternately from the ice cap of the north and that of the south, it has been possible to produce harvests in the temperate regions of the Martian equator.

In this argument the assumption lies in the two ice caps. The earth, its atmosphere of great richness in aqueous vapor and at a tension where precipitation is frequently possible over wide areas, certainly has ice caps. The opponents of Schiaparelli and Lowell deny the Martian ice caps.

Mars has spots of polar brightness which wax and wane with close and very rapid correspondence with the change in the angle of incidence of the sun's rays thereupon. It is argued that if the Martian atmosphere was so rich in aqueous vapor as to form these vast polar areas of ice it would be so rich that, under any comprehensible theory of convection and atmospheric circulation, it would be impossible for it to be so arid in its equatorial and midway regions as to call for any system of irrigation at all.

Furthermore, in opposition to the canal theory, it is held that if it really be ice at the polar caps, and knowing as we do the number of thermal units effective when the sun returns to shine upon each cap after its winter night, we cannot account for the rapidity with which the cap disappears in the sunlight. It vanishes with such speed that some observers have spoken of it as almost an evaporation, some such process as in the physics of the terrestrial atmosphere is observable in the warm Chinook winds of our northern Rocky Mountains, where whole fields of snow vanish as if dried up, the same phenomenon on the European Continent being equally familiar as the foehn of the Alps.

So rapid is this disappearance of the bright spots in the circumpolar region when the sun dawns upon it that it is too rapid even to admit of the inference that it is only snow. It is said that nothing but hoar frost will at all answer the conditions observed. If the Martian atmosphere has so little vapor of water that its maximum polar deposits amount to no more than frost it is clear that the evaporation constant must be so high that no canal could possibly carry the collection of drops from a region of melting rime as far as the equator of a planet as great as our own or beyond the equator into the cold atmosphere as the theoretical conditions demand.

This dilemma may thus be stated. If the water vapor in the Martian atmosphere is sufficient in amount to yield an ice cap at the polar bright spots the tension over the rest of the planet must be such that canals will not be needed because of a sufficient precipitation; if the water vapor content is so slight that the polar caps are nothing but frost, no amount of engineering skill could cope with the tension which would evaporate whatever water may have started in the canals. Under terrestrial conditions these two extremes are well represented by the Hudson, which never runs dry, and those rivers of the arid West which are greatest at the source and dwindle on their course until they end in a damp spot with bone dry edges.

Before our philosophy can make much headway in the dicussion of the Martian intelligence it will be necessary to arrive at some solution of this critical question. What is the amount of the water vapor in the atmosphere of the red planet?

Fortunately we are not without appliances which may deal with this fundamental problem. The spectroscope yields a record of the constituents of every sort of light which it dissolves, and the bands corresponding to water vapor have all been plotted on the spectrum. If these bands show at all, it is irrefragable evidence of the presence of water vapor, and in like manner the pronouncement of their definition gives a measure of the amount of such water vapor. If then comparative observations are made simultaneously of an illuminated object whose water vapor content is well established and of Mars, in which it is yet to establish that factor, the comparison of the bands in the two spectra will give a measure of the result in Mars.

At the very favorable opposition in September the whole resource of the Lick Observatory staff was devoted to the making of this comparison.

In order to avoid as much as possible of the water vapor content of the earth's atmosphere, greatest in the lower levels, the observing station was equipped on the summit of Mount Whitney in the Sierras at the elevation of 14,501 feet and in a horizon markedly arid. Co-ordinately with the astronomical observations, physical measurements were made of the exact amount of water vapor there present in the air.

For purposes of the astronomical comparison the moon was taken as the standard. A long series of eclipse observations has shown that whatever atmosphere may persist about our satellite is optically indiscernible. Similar series of spectroscopic observations have shown that the water vapor at the moon is wholly inappreciable by the most delicate tests. If the spectrum of Martian light photographed under the same terrestrial condition shows no more water vapor bands than appear in the photographed spectrum of lunar light the conclusion is warrantable that water vapor on Mars is of such extreme tenuity as not to be made available for cultural purposes.

The complete results of the Mount Whitney observations have not yet been worked out, but Director Campbell authorizes the preliminary report that the comparison of simultaneous Martian and lunar spectra proves that Mars has no more water about it than has the moon. He is concerned in the determination of this one fact in physics. The rest follows in its train of inexorable logic. If Mars has no more water than the moon the polar bright areas cannot be ice, snow or hoarfrost; the most reasonable suggestion is that they are solidified carbon dioxide, the heaviest constituent of an atmosphere and the longest to linger over a dead world, itself a mantle of death and the shroud of animal life.—The New York Sun.

DOMESTIC DOGS THAT HAVE BECOME WILD.

It is well known that domestic animals occasionally run wild. They appear to adapt themselves to this change in habits and conditions without difficulty. The writer has observed many dogs that had run wild, and that closely resembled their wild congeners in psychical behavior, as well as in bodily movements. In dogs that have become wild, the characteristics of the beast of prey are strongly marked. They do not again seek human habitations, except when compelled to do so by severe weather, exhaustion, or hunger. In some cases they entirely give up association with man, and become formidable marauders in game preserves. About ten years ago a forest on the lower Rhine was ravaged for weeks by two large dogs, which were finally discovered in the act of chasing a deer. The forester shot and killed the dogs, but not before they had charged, and one of them had nearly reached him.

Extensive and long-continued depredations upon poultry in a district of Germany a few years ago were finally traced to two dogs, which were tracked and killed by an experienced huntsman with considerable difficulty. The dogs had made a lair in a rye field, where great quantities of feathers and bones were found. Dogs that have run wild are apt to hunt in couples, and frequently one dog is enticed away by another. The slumbering predatory instinct is awakened by a sportive chase of a hare, and a few captures of young and disabled animals arouse it to full activity. Such dogs spread terror through the Westerwald last winter by killing so many deer that their ravages were attributed to wolves. Another interesting instance of reversion to primitive instincts was furnished by a bitch that dug a hole in a field and there gave birth to her litter, although she possessed every convenience for the establishment of her family in her master's home, where she was well cared for and kindly treated.—Prometheus.

In a new process for making a substitute for India rubber, the materials used are animal refuse capable of yielding gelatine, oils, sulphur, chromates, and sodium stannate, the addition of the last-named salt being the distinguishing feature of the process.

ENGINEERING NOTES.

The South American Railway Congress, which will meet at Buenos Ayres during the International Exhibition of Railways and Land Transport to be held there from May to November, 1910, will consider, among other matters, questions relating to the most convenient gage, systems of signaling, motor car service, and electrification of suburban trains.

The Brown-Boveri firm has recently finished building an 11,200-horse-power steam turbine for the electric station of Buenos Aires, and there are to be used ten such turbines in the plant. The group is composed of a Parsons wheel running at 750 revolutions per minute and coupled to two alternators. An overload of 14,200 horse-power can be put on temporarily. Superheated steam at 300 deg. C. is used, with a surface condenser. For a 7,500-kilowatt load the steam consumption is 14 pounds per kilowatt-hour. The weight of the whole turbine set including the condenser is about 800 tons. The turbine is formed in two parts with intermediate bearing so as to secure a great number of sections in the wheel, and this is found to increase the yield.

A project is on foot for building an international dam across the Niagara River to maintain the water level of Lake Erie at not less than a certain minimum height, the year round. Every autumn the level falls so as to seriously interfere with shipping, and it is for improving the present condition that the dam is considered. If built, the dam could be used for another purpose equally laudable and valuable. There has been much agitation against the defacement of the natural beauty of Niagara Falls because of the amount of water used by the power companies, which materially reduces the volume of flow over the falls in low-water periods. The dam could be used to impound water at night, practically cutting off all flow for certain hours through the night and storing it for use in the daylight hours. In this way it would be possible for the power development of Niagara Falls to be materially increased for daylight service without decreasing the normal volume of flow, the daylight flow being sufficiently in excess of the normal flow to compensate for that used by the power concerns.—Machinery.

In the American Engineer and Railroad Journal Mr. S. S. Riegel records some interesting tests upon model half-boilers of locomotives. The models were approximately to scale, one half-boiler being of the standard type, and the other provided with the Riegel water tubes arranged at an angle over the fire, between the mud ring and crown sheet of the fire-box. The tests were conducted at atmospheric pressure with scaly water. The general results showed a greater evaporation of about 50 or more per cent in favor of the cross-tube design, although, as the models were short in the barrel, this percentage would be somewhat less in practice. The cross tubes were found to promote a very active circulation about the fire-box, and kept it free from scale, which was, however, deposited on the outside of the plain fire-box. In comparing the performances of the two types of fire-box it should be pointed out that the cross-tube boiler had also 10 per cent more tubes in the barrel than the standard, and since both boilers were heated by the same fire and fed into the same chimney it is clear that the bulk of the hot gases would be drawn through the new type of boiler. Indeed, it is thought probable that the greater part of the extra evaporation obtained was due to this cause.

The fuels we have at our disposal for the commercial generation of heat may be tabulated as follows together with their calorific values:

Average Thermal Value of Fuels.

Solid Fuel.	British Thermal Units per lb.
Coal:	
Newcastle and Welsh	15,200
Lancashire and Derbyshire	14,600
Anthracite	15,600
Coke	14,300
Peat:	
20 per cent water	7,200
5 per cent water	9,900
Wood (average)	8,600
Charcoal	14,600
Liquid Fuel.	
Petroleum (fuel):	
American and Russian	19,500
Caucasus, Borneo, Burmah	18,700
Blast-furnace and tar oils	16,000
Alcohol, absolute	12,931
Alcohol, 10 per cent water	11,520
Alcohol, methylated	11,160
Gaseous Fuel.	
Natural gas	21,615
Coal gas (London 16 c. p.)	19,220
Water gas (blue)	7,980
Mond gas	2,525
Dowson gas	2,353
Suction plant gas	2,160
Air-coke gas	972
Blast-furnace gas	951

ELECTRICAL NOTES.

A wireless telegraph station at Copenhagen was recently opened to the public. This station is used for the exchange of messages between ships and the shore, and communication, under normal conditions, is possible over a distance of 187 miles. All Danish telegraph offices accept messages for transmission by wireless telegraphy.

An additional advantage claimed for electric welding of rails is the reduction of corrugation of the surface by traffic and the resultant noisy running of the carriages. Electric railway authorities in Berlin, Hamburg, and Bremen claim that the welding of a strip of soft iron to the rail surface not only prevents corrugation, but reduces the noise due to corrugations already made.

The transfusion of particles of different kinds of metals through the agency of electrical current has been held by some to take place just the same as in the case of electrolytes. To prove or disprove this contention an experiment has been recently carried out on a system composed of aluminium and copper, through which an electrical current was passed continuously for one year. After the two parts were separated it was found that neither metal contained any particles or traces of the other.

A new system of telegraphing half-tone photographs has been introduced, and is at present in operation between London and Manchester. It is claimed that a half-tone photograph containing seventy-five or more lines to the inch can be wired very rapidly, while the transmitted picture is received direct, without the intervention of photography, upon a plain sheet of specially sensitized paper, the sensitiveness being electro-chemical, not photographic. It is stated that a photograph nearly whole-plate size can be transmitted in less than ten minutes.

A patent recently issued, says the Electrician, describes a method of improving steel produced in electric furnaces. The steel, previously refined in a basic electric furnace, is passed into a crucible with an acid lining and allowed to settle. A mechanical readjustment takes place, the steel taking up silicon, which, it is claimed, has a favorable influence on the internal structure of the steel. In addition, the production of iron alloys or the addition of modifying agents can be easily controlled. The latter is accomplished by passing the unalloyed steel into the crucible before adding the modifying constituents.

According to the Electric Journal, the following method for drilling slate and marble has been found to give excellent results: Use ordinary twist drills for holes 1½ inch or less in diameter, giving the lip plenty of clearance; above this size, wing cutters will give better results. Keep tool thoroughly wet with water while cutting, and keep clean to avoid jamming. A speed of 400 revolutions per minute for ¾ inch or less and 200 revolutions per minute above ¾ inch will be found satisfactory. Feed by hand and be careful when nearly through, as the material is apt to break off in large pieces; for this reason a machine feed is not desirable.

An article by an "Austrian Engineer," in a recent number of the Electric Railway Journal, gives some details relating to electric railway conditions in Austria. The first single-phase railway in the world, the Stubaitalbahn, was built in the Tyrol, and the absence of coal and the large amount of water-power have given great impetus to the construction of electric railways. Recent statistics indicate that there are about 5,500,000 horse-power available in the water-power of Austria, or 187 horse-power for each 1,000 inhabitants. This amount is surpassed only in Switzerland, where there are 454 horse-power for each 1,000 inhabitants. The figures showing the percentage of utilized to available power are, in Switzerland, 25 per cent; Germany, 20 per cent; France, 18 per cent; Italy, 14 per cent; and Austria only 9 per cent. A commission appointed by the government is now systematically studying the subject of utilizing all the available water-power for electric traction.

In a paper read before the fifth annual meeting of the Illinois Gas Association, the author said that he considered clean coal tar pitch, free from water acids or soluble mineral matter, as the most efficient type of covering for the prevention of soil and electrolytic corrosion of iron pipes. Such a pitch, he states, should be as hard as it is possible to make it without being brittle at ordinary temperatures, and should not crack when struck a hard blow. The pipes to be coated should be smooth, free from moisture, rust and loose scale, or any foreign matter. Projections on the surface should be filed down before coating. The clean pipe should be left in a melted bath of pitch until the metal and dip are of the same temperature, which should be just sufficient to melt the pitch to a uniform liquid condition. The pipe, when removed, should have a smooth, uniform, black, glossy coating, 1/32 inch thick and free from lumps, bubbles or foreign matter.

TRADE NOTES AND FORMULÆ.

To Color Zinc Surfaces Black.—Dip the zinc object in a weak solution of blue vitriol, dry it by the application of moderate heat, rub it off well with a dry piece of cloth and finally wipe it over with a piece of flannel on which a few drops of olive oil have been dropped.

To Utilize Sandpaper Fully.—Glue each two sheets back to back. The paper is thereby greatly strengthened and can be used up to the last corners. When using it, if it becomes limp, owing to the heat and moisture of the hands, it should be dried and can then be used until completely worn out. In order that the sheets do not curl up when glued they may be subjected to light pressure between the boards. Paper glued up in the manner described is especially desirable for large work.

Plastic Mass.—A mixture of wood shavings and rosin is heated in a boiler shaped like a distilling retort with a hood until the rosin oil is distilled off and the wood is partly transformed into tar. By this means, with 30 to 50 per cent of rosin in the mixture, it is possible to produce a very tenacious mass (which can be used for fire and coal kindling or as lumber) whereas hitherto in compressed kindlings the mixture had to contain 70 to 80 per cent of rosin, consequently a disproportion to the extent of the use of the wood shavings as a waste product.

Soap Milk (benzine emulsion), a spot-removing preparation, is obtained by emulsifying benzine with opodeldoc soap. 3 parts of this soap are dissolved in 50 to 60 parts of distilled water and 1,000 parts of a mixture of equal parts of benzine, ether, and petroleum-ether are added gradually, each addition being vigorously shaken. The emulsification is accelerated if the mixture is placed now and again in warm water. The finished emulsion is allowed to stand at rest for a few days, to permit the superfluous water to collect at the bottom of the bottle.

Soap Leaves.—10 parts of glycerine, 30 parts of alcohol, 60 parts of dry glycerine soap, and 50 parts of ordinary neutral soap form the mixture with which the paper is impregnated. This is effected in a trough containing the mixture, which is kept at a temperature of 165 deg. to 180 deg. F. In the trough there are three rollers driven by steam or other power revolving in the same direction and over the under side of which the paper is passed. While under treatment the paper is sprayed with small quantities of oil of turpentine, which causes it to dry more rapidly and also imparts to it an attractive glossy appearance.

Preparation of Polish.—In preparing a good, lasting polish it is important that only 96 per cent alcohol be used. For a light polish 100 parts of orange shellac and 1,000 parts of 96 per cent alcohol will suffice; for a darker polish 100 parts ruby shellac and 1,900 parts of 96 per cent alcohol. The shellac is reduced and kept with the alcohol in a loosely-corked bottle; it is not necessary to heat it, but the mixture must be frequently shaken. White polish is made by first dissolving bleached shellac in ether or wood spirit and then adding 96 per cent alcohol in the proportion of 1 to 10. Colored polishes are usually prepared with additions of aniline colors dissolved in alcohol, but only spirit-soluble aniline must be used.

Dressings.—I. 100 parts of boiling water, 0.300 part of licorice juice, 0.560 part gum solution, 0.560 part copper vitriol, 0.004½ part starch, 0.100 part laundry blue, 0.500 part cherry laurel water, boil for a half minute. II. Prepare a sticky extract of 180 parts of water, 5 parts glue, 10 parts hide trimmings, by boiling it for 24 hours with steam, then add as much alum as may be needed to preserve the animal matter. The fluid thus obtained is mixed with a slimy extract prepared from 7 parts of linseed and 100 parts of water by ten hours boiling. To this mixture is added 25 parts sago flour and 50 parts of water stirred together. III. 150 parts of water, 14 parts of potato starch, small quantities of sulphate of soda, glue, and blue vitriol. IV. 1 part of soft soap, 2 parts of tallow, 2 parts of soda, 246 parts of wheat flour.

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